THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. VII.

No. IV.—APRIL, 1900.

ORIGINAL ARTICLES.

I.—Notes on the Geology and Fossils of some Devonian Rocks on the North Coast of Cornwall.

By Howard Fox, F.G.S.

(PLATE VII.)

DURING the past year I had the pleasure of spending some weeks on the north coast of Cornwall, south of the Camel, examining the rocks exposed in the cliffs and on the foreshores of the various coves, some of which I had not previously visited. A part of my notes were communicated to the Annual Meeting of the Royal Geological Society of Cornwall last November, and with the permission of the Society I propose to reproduce these and additional observations obtained since, with the view more particularly of calling attention to some of the fossils which, though fragmentary, appear to me to yield not unimportant evidence on the stratigraphical horizon of the rocks along certain parts of the coast.

It had been my intention to visit the various islands lying off the north coast, but during my holiday month, September, there was not a single day in which it would have been prudent to attempt a landing either on the Quies Group or the Bull Rock off Trevose Head. I did, however, make a brief visit to Gulland Island, which is, rightly, coloured greenstone on the Geological Survey Map. The entire surface of this island is covered with angular weathered fragments, which have been disjointed off from the massive rock, a process still rapidly going on. The lower cliff on the south side of the island is composed of a coarse-grained felspathic rock, whilst higher up the rock is of the same kind but much finer grained. The exposed rock surfaces, within reach of the waves and spray, weather nearly black, whilst the rocks beyond are of a rusty-brown appearance.

Padstow Harbour.—In the rocks both to the north and to the south of the River Camel, simple cup-corals and fragmentary crinoidal remains occur, but for the most part they are unfavourably preserved.

Trevone.—An account of the fossils present at several distinct horizons in the shales at this place, and more especially on the foreshore, has already appeared in the Trans. Roy. Geol. Soc.

Cornwall, vol. xi, 1894, pp. 634–644. The following, amongst others, were noted: fragmentary plates of *Pteraspis*; *Orthoceras*; *Bactrites*, including *B. Budesheimensis*, Ferd. Roemer; *Goniatites*; G. (*Tornoceras*) *simplex*, Von Buch; *Euomphalus*; *Cardiola retrostriata*, Von Buch; *Centronella*, *Phacops*, *Tentaculites*, *Styliola*, *Amplexus*, *Favosites*, and *Pachypora*. According to Mr. G. C. Crick the majority of the Cephalopod remains indicate the same geological horizon as the Budesheim Beds, that is, the lower portion of the Upper Devonian, but with these there are some small forms resembling *Anarcestes latiseptatus*, Beyr., and *Mimoceras compressus*, belonging to the Wissenbach (Nassau) Beds, of Lower and Middle Devonian age. On visiting the locality again, after an interval of six years, I was disappointed at not finding any new forms exposed by the ceaseless scour of the waves and sand on the rocks.

West of Newtrain Bay.[1]—The shales here contained some fragmentary crinoidal arms, which were determined by Mr. F. A. Bather to be of a nearly similar character to those of *Scaphiocrinus*, Hall, as figured by the Rev. G. F. Whidborne from the Pilton Beds near Barnstaple (see "Dev. Fauna S. of England": Pal. Soc., 1898, vol. iii, pt. 3, pp. 228–232, pls. xxxi, xxxiii–xxxviii).

Mother Ivey's Bay.—A shelf of blue shale is exposed at the east end of the beach at this place, near high-water mark, which contains fragmental crinoidal stems, pyritized examples of *Tentaculites*, and *Centronella* similar to those occurring at Trevone, and, in addition, a specimen of *Hyolithes*.

Porthcothan Cove.—This picturesque cove is about three miles south of Trevose Head. The rocks are of a bluish, non-calcareous shale, showing a general dip E.N.E. at 15–20°. Fossils do not appear to have been previously noticed in them, but they contain a fair number, though for the most part in poor preservation. The following have been recognized:—*Petraia*, in casts showing the outlines of the cup and septa, are not uncommon. Two species appear to be represented; one may be *P. celtica*. *Pleurodictyum*, sp., described below, fragments of *Conularia* similar to those from Constantine Bay (Trans. Roy. Geol. Soc. Cornwall, 1894, p. 643), imperfect pygidia of Trilobites,[2] and obscurely shown examples of *Orthoceras* and *Goniatites*.

Porth Mear.—This cove is about half a mile south-west of Porthcothan, and the rocks enclosing it are of the same character. On the foreshore several distinct fossiliferous bands are exposed; one of these can be traced for a distance of 40 yards nearly due east from the north end of the island; numerous specimens of *Pleurodictyum* are weathered out of its surface.

Lower Butter Cove.—The same kinds of rocks and fossils noted from Porthcothan and Porth Mear are likewise found in this cove, which is about half a mile south-west of the last-named place. The fossiliferous beds are visible at low-water, at the base of the eastern

[1] At the Bay itself I have since found two species of Favosite corals.

[2] A Trilobite minus the head, which I have recently obtained here, has been determined by Dr. H. Woodward to be a species of *Phacops*.

cliff of the southern inlet. Huge blocks of rock fallen from the cliffs above likewise contain numerous fossils.

Bedruthan Steps.—The fossiliferous character of the claret and bluish shaly or slaty beds of this locality has long been known. Mr. S. R. Pattison states that they contain crinoidal remains, a bivalve shell, and impressions of a Trilobite (Trans. Roy. Geol. Soc. Cornwall, vol. vii, 1848, p. 48); and in the same volume (p. 391) the late Mr. W. Pengelly notes the occurrence in them of the plates of *Steganodictyum*, McCoy (*Pteraspis*), then supposed to be a fossil sponge. The fossils are present, in great abundance, in the lower part of the cliff and on the foreshore, and in the large fallen rock masses. Some years since I obtained here fragments of fish-plates, principally of *Pteraspis*; *Orthoceras*?; the basal plate of a crinoid resembling *Sphærocrinus*, and fragments of crinoid stems which may have belonged to *Rhodocrinus* or *Melocrinus*; simple cup-corals, apparently zaphrentoid in character; *Pleurodictyum* and *Aulopora*? Last autumn I further obtained *Petraia*; a fragment of a Monticuliporoid; crinoidal fragments, one of which has been determined by Mr. Bather as the anal tube of a dicyclic adunate crinoid; and specimens of the peculiar form described below as *Pteroconus mirus*.

Watergate or Tregurrian Bay or Beach.—This range of beach and cliff extends about $2\frac{1}{4}$ miles north of St. Columb Porth, and it is noted for the variegated colouring of its slates. Similar rocks occur between Fowey and Polperro, and according to Mr. W. A. E. Ussher they are also present in South Devon, where they are known as the Dartmouth-Kingswear Slate group. Professor Sedgwick states (Quart. Journ. Geol. Soc., 1852, vol. viii, p. 4) with respect to these rocks, that he found a highly fossiliferous group extending from New Quay to Mawgan Porth and Padstow, and thence to Tintagel; not merely ranging near the coast, but running far up the interior of the country until, in some instances, it approached a central boss of granite.

On close examination I found indications of fossils throughout the whole series of the variegated slates or shales of the Bay, though they are, as a rule, so poorly preserved that only occasionally can the nature of the organism be recognized. Fragments of *Pteraspis* plates are not infrequent in satiny grey soft shales exposed on both the north and south banks of the small stream running into the sea north of the noted Watergate Elvan; and also in a bed of soft blue shale the *Pteraspis* plates, though fragmentary, are in great abundance.

The fossils mentioned above, which I have obtained from these north coast rocks from time to time, have been submitted to various authorities at the British Museum (Natural History), to whom I am greatly indebted for their efforts to decipher the characters of the forms usually very imperfectly preserved. Dr. A. Smith Woodward, F.L.S., has determined the fish remains, Mr. F. A. Bather, M.A., the Crinoids, and Mr. G. C. Crick, F.G.S., the Cephalopods, etc. Further, Dr. G. J. Hinde, F.R.S., has examined the Corals and doubtful forms. On the accompanying plate some of the fossils,

which appeared to be of sufficient interest to justify figuring, have been skilfully represented by Miss G. M. Woodward, and the following notes are appended in explanation of them, beginning with the fish remains.

Pteraspis Cornubica, McCoy, sp. (Pl. VII, Figs. 7, 8.)

This species is represented by irregularly shaped, flattened fragments of the dermal plates, which are scattered, sometimes singly, sometimes in close juxtaposition, and even occasionally overlapping each other, on the exposed surfaces of the bluish-grey shales at Watergate Bay. The plates are black, sometimes glossy in appearance, and their exterior surfaces are ornamented with fine ribs or striæ running parallel to the length of the plate. The striæ are in places interrupted so as to look like a series of minute tubercles, only visible under a lens, and in some instances they are crossed transversely by lines of growth. The plates vary from 0·5 to 1 mm. in thickness, and there are about four of the surface striæ in a millimetre. These fragmentary plates have been identified by Dr. Smith Woodward as similar to those of *Pteraspis Cornubica* which occur in the Devonian rocks of Lantivet Bay, South Cornwall, and of which he has lately given an interesting account (Trans. Roy. Geol. Soc. Cornwall, vol. xii, 1899, p. 229).

These fragments are found at Bedruthan Steps as well as at Watergate Bay. According to Dr. S. Woodward the genus *Pteraspis* is characteristic of the Lower Devonian or Lower Old Red Sandstone in Western Europe, and does not descend below this horizon (Catalogue of Fossil Fishes in the British Museum, vol. ii, 1891, pp. 160–169).

Phlyctænaspis, sp. (Pl. VII, Figs. 5, 6.)

The only specimen referable to this genus is a thin plate, part of which is shown on the surface of a light-grey shale and part still enclosed in the rock. The plate is not entire; in one direction it is shown for a distance of 55 mm., and it is about 0·5 mm. in thickness. The upper surface, nearly of the same grey tint as the matrix, is furnished with numerous small depressed tubercles, rounded or oval in outline, and about 0·5 mm. in diameter. They are arranged alternately in rows, between three and four in the distance of 2 mm. The summit of these tubercles is often wanting, and the rounded dome is replaced by a minute crater.

Dr. Smith Woodward states that owing to the incompleteness of the plate it is not possible definitely to identify it with *Phlyctænaspis*, but the tubercular surface is approximately similar to that of the plates of *P. acadica*, Whit., sp. (see Geol. Mag., Dec. III, Vol. IX, 1892, p. 5, Pl. I, Figs. 7, 8), from the Lower Devonian at Campbellton, New Brunswick. The Canadian fossil, of which a specimen is in the British Museum (Nat. Hist.), has stouter tubercles with striæ radiating from their bases, and they are more deeply hollowed out than in the present form.

The specimen is from Watergate Bay. The genus *Phlyctænaspis* is characteristic of the Lower Old Red or Lower Devonian.

Climatius, sp. (Pl. VII, Figs. 9, 10.)

The only example is a fragment of a compressed spine, 9 mm. in width and 2 mm. in thickness; the exposed surface is jet-black; it shows stout, straight, longitudinal ribs, of which there are eight in the width of the spine. The upper edge of the ribs is, in places, tuberculate, and on one side of each there are, at intervals, blunted processes which reach across the interspace between the ribs so as to form elongate hollows, now filled with matrix. According to Dr. Smith Woodward the structure of this spine resembles that of the spines of the genus *Climatius*, Ag., which has a dermal spine in front of each fin except the caudal.

The specimen figured is from Watergate Bay. The genus occurs in the Lower Old Red of Forfar, Hereford, and Worcester, and in the Lower Devonian of New Brunswick.

The occurrence of the remains of *Pteraspis*, *Phlyctænaspis*, and *Climatius* in the same series of shaly strata at Watergate Bay and Bedruthan Steps derives significance from the fact, brought to my notice by Dr. Smith Woodward, that in other regions of Western Europe and Eastern North America where these three genera are present, they characterize the geological horizon of the Lower Old Red Sandstone or the Lower Devonian. It may therefore be reasonably assumed that the rocks on the North Cornish coast in which they are found likewise belong to the same geological period.

The following descriptions of *Pteroconus mirus*, n.sp., and *Pleurodictyum*, sp., have been contributed by Dr. G. J. Hinde, F.R.S.:—

Family HYOLITHIDÆ, Nicholson.

Genus PTEROCONUS, Green (= NEREITOPSIS, Green).

Pteroconus mirus, sp. nov. (Pl. VII, Figs. 1–4.)

Shell conical, compressed, straight; in transverse section round or elliptical, on both sides with small shelly flap or fin-like extensions disposed at regular intervals from the basal point to the summit aperture. A longitudinal rod or thickening of the shell enclosed within the cone. The outer surface with an ornamentation of transverse lines of growth following the contour of the summit, and at intervals with stronger raised lines connected with the lateral processes. No operculum has been observed.

This description is based on the characters shown by a number of specimens collected by Mr. Howard Fox at Bedruthan. The fossils are exposed on the surface of a bluish or claret-tinted shaly rock as they have been naturally weathered out; in some the shelly exterior of the test with its ornamentation is visible, whilst in others the interior of the cone has been laid bare. The forms are to some extent compressed in the shaly rock, and only the surface weathered in relief can be studied. The test is now of a brownish or reddish-brown tint, owing to the replacement of the original shell by some compound of iron; the interior is now generally filled with the shaly matrix. Only exceptionally are perfect specimens met with;

as a rule the summit apertures are defective, but on the whole these fossils are better preserved than other organic remains in the same rock.

The specimens are variously elongate, gradually tapering cones, ranging from 30 mm. to 72 mm. in length and with a summit breadth of 7–9 mm. The most complete example (Pl. VII, Fig. 1) is a cone, 35 mm. in length, showing the outer surface of the test, but the ornamentation is only distinguishable in its upper portion. The upper margin, apparently perfect, has a gently convex outline, and including the lateral processes is about 9 mm. in breadth. The surface of the central cone exhibits delicate arched growth-lines following the contour of the aperture, and at intervals of about 2·5 mm. it is crossed by stronger raised lines, which on either side of the cone are prolonged downwards to form the anterior margins of small flattened or slightly concave processes or flaps, which extend obliquely for a distance of 1·5–2 mm. from the cone. There are in this specimen sixteen of the ear-shaped processes; they are disposed so that the posterior margin of each dips slightly under the front edge of the one next below it in the series. The three or four processes on either side of the lower part of the cone appear to have coalesced together so as to form a narrow continuous plate, which extends round and slightly beyond the point of the cone. In another specimen, 72 mm. in length, there are about thirty-four pairs of processes, which are somewhat triangular in outline. A transverse section of a specimen similar to Fig. 1 is distinctly elliptical in outline.

In the form represented in Pl. VII, Figs. 2 and 3, the cone has been weathered so as to expose the interior longitudinal rod or thickening of a portion of the interior of the test. The specimen is imperfect, and a joint in the shale has divided it into two parts. Above the fracture, the exterior of the test is shown crossed by striæ with a slightly concave curve, whilst below the line of fracture the interior of the cone is laid bare by weathering, and a central rod-like body, unequally thickened at intervals and bordered by depressions on either side, projects slightly above the bordering wall of the test (Pl. VII, Fig. 3). The lateral flaps or processes are very distinctly striated, and in contrast with those of the specimen mentioned above (Fig. 1) the processes and the striæ have a slightly upward direction. This difference may perhaps be explained by supposing that the side of the shell exposed in this example is the reverse of that shown in Fig. 1. Owing to the fact that only one side of a specimen can be examined, it is not practicable to determine if the characters of the dorsal or ventral side in this form are similar or not.

Another aspect of the interior rod is seen in the middle half of a specimen (Pl. VII, Fig. 4) in which the striated shelly exterior has been weathered away. It here appears as a straight, slender, nearly smooth, cylindrical rod, just within the wall of the cone. In the short length of it exposed there is no connection with the lateral processes apparent. The nature and function of this interior rod

are problematical. At first it suggested the idea that it might indicate a siphuncle, but there is no evidence that it was a hollow tube. Mr. G. C. Crick, who has most carefully examined these fossils, is unable to recognize in them any genuine Cephalopodan characters.

The real nature of these forms has been a subject of much speculation alike to the writer and to other palæontologists who have examined them. They present several points of resemblance to the Hyolithidæ in their general form, size, the character and ornamentation of the shell, and even the peculiar flaps or lateral processes may be looked upon as analogous to the winged expansions in *Pterotheca*, Salter, and *Pterygotheca*, Novak. I am unable to say at present whether any structure occurs in known Hyolithidæ which can be compared with the interior rod-like body in *Pteroconus*. On the whole there seems sufficient justification for regarding this genus as belonging to the Hyolithidæ. The systematic position of this family is still a matter of debate, and its relations to the Pteropoda have not been certainly proved.

Whilst working at the specimens sent to me by Mr. Howard Fox, my attention was called to the figures of some casts of fossils from Polruan, etc., by Mr. Upfield Green, in the Trans. Roy. Geol. Soc. Cornwall, vol. xii (1899), pt. 4, pl. F, p. 227. Through the kindness of Mr. Green and Mr. J. H. Collins, I had an opportunity of seeing the originals of the figures which are preserved in the Museum of that Society at Penzance, and at once recognized them as casts of organisms similar to those discovered by Mr. Fox. Mr. Green did not describe the forms, but limited himself to giving the figures and naming "the fossil *Nereitopsis cornubicus*, from its somewhat distant resemblance to some of the species of the genus *Nereis* (Cuvier) of the dorsibranchiate order of Annelids." I pointed out to Mr. Green that the fossils themselves, as distinct from the casts, precluded the idea that they could in any way resemble any species of *Nereis*, and that consequently the name he proposed was misleading and should be changed. Mr. Green accepted my suggestion and desired to substitute *Pteroconus* for *Nereitopsis*, and I have adopted his fresh name as that of the genus. Mr. Green states that the larger of his specimens (fig. 1, pl. F) "differs from the others, being terminated posteriorly by a tuberculated extension," and this may properly be considered as the type of *Pteroconus* (*Nereitopsis*) *Cornubicus*. Whether the other forms represented in his figures are new species or will prove to be the same as those described and figured in this paper must remain at present undecided.

The specimens of *Pteroconus mirus* were collected by Mr. Howard Fox in the claret-tinted and bluish shales, probably of Lower Devonian age, exposed in the cliffs and foreshore at Bedruthan Steps, North Cornwall. Mr. Fox has announced his intention to present the specimens figured to the British Museum (Natural History), Cromwell Road, South Kensington.

Pleurodictyum, sp. (Pl. VII, Fig. 11.)

Corallum discoidal, thickness inconsiderable, the upper surface depressed convex, diameter from 25 to 34 mm. There are about

ten large corallites in what appears to be a full-sized corallum, with smaller corallites in the angles between the larger. The corallites range from 5 to 9 mm. wide, their average diameter is 7 mm. They are polygonal or rounded in outline, shallow, the walls are relatively thick and apparently vesicular, showing small irregular interspaces on their weathered margins. There are indications of pores passing through the walls near the base of the corallites and communicating with the exterior, but it is uncertain if the corallites were directly connected with each other by mural pores. A few blunt spines are present in the lower portion of the corallites, but there are no indications either of tabulæ or septal striæ.

Examples of this form are by no means rare, but they are all very poorly preserved, and but little more than their upper surfaces, slightly projecting from the bluish shaly rock, can be distinguished. Their walls have been replaced by a mineral which gives a very slight reaction with acid. So far as comparison is possible, the form to which they are nearest allied is *P. granulifera*, Schlüter (Anthoz. d. rhein. Mittel-Devon. Abhandl. der geol. Landesanst., vol. viii, 1889, p. 361, pl. iv, figs. 5–8), from the Middle Devonian of the Eifel. According to Mr. C. W. Peach, *P. problematicum*, Goldf., also occurs in abundance at Polruan and other localities in Cornwall (Trans. Roy. Geol. Soc. Cornw., vol. ix, p. 52), but I am unaware if this determination has been confirmed.

It seems desirable not to give a specific name to the present form until better preserved specimens have been obtained. It is found at Porthcothan, Porth Mear, and Lower Butter Cove.

EXPLANATION OF PLATE VII.

Fig. 1.—*Pteroconus mirus*, Hinde, sp.n. Showing the exterior surface of a fairly perfect specimen, weathered out on the surface of a shaly rock. Natural size. Lower? Devonian: Bedruthan Steps, North Cornwall.

Fig. 2.—The same. An imperfect specimen from the same locality, the exterior surface shown in the portion above the line of jointing, and below this the interior of the cone with the lateral processes are exposed. Natural size.

Fig. 3.—The same. A part of Fig. 2, enlarged three diameters, showing the longitudinal rod within the cone and the striation of the lateral processes.

Fig. 4.—The same. An imperfect specimen showing in the middle portion the inner rod, exposed by the weathering away of the shell. Natural size. From Bedruthan.

Fig. 5.—*Phlyctænaspis*, sp. A fragment of a plate weathered out on a surface of shale. Natural size. From the Lower Devonian of Watergate Bay, North Cornwall.

Fig. 6.—The same. A portion of Fig. 5, enlarged ten diameters to show the tubercles, one of which is hollowed out.

Fig. 7.—*Pteraspis Cornubica*, McCoy, sp. An imperfect shield-plate, showing the striæ and lines of growth. Natural size. From the Lower Devonian at Watergate Bay.

Fig. 8.—The same. A portion of Fig. 7, enlarged five diameters.

Fig. 9.—*Climatius*, sp. A fragment of a spine, showing the strongly marked ribs with their lateral processes. Natural size. From Watergate Bay.

Fig. 10.—The same. Part of Fig. 9, enlarged five diameters.

Fig. 11.—*Pleurodictyum*, sp. The upper surface of a specimen, partly weathered out of bluish shale. Natural size. From the Lower Devonian at Porthcothan, North Cornwall.

II.—Notes on *Drepanaspis Gmündenensis*, Schlüter.

By Dr. R. H. Traquair, F.R.S.

THIS most remarkable fish, from the Lower Devonian Roofing Slate (Hunsrückschiefer) of Gmünden, in Western Germany, was named, but very imperfectly described, by Schlüter in 1887, as his material was at that time of a very fragmentary nature. He apparently considered the creature to be allied to *Cephalaspis*. In Dr. Smith Woodward's "Catalogue" (pt. ii, 1891, p. 311) it is only mentioned by name along with a number of other imperfectly known forms (*Aspidichthys*, *Anomalichthys*, etc.) which he considered as "perhaps for the most part" referable to the Coccosteidæ.

In 1890 I began to obtain specimens, at first very fragmentary, through the agency of Mr. Stürtz in Bonn, and in exhibiting these before the Royal Society of Edinburgh, I expressed the opinion that the affinities of *Drepanaspis* lay rather with the Pteraspidæ (*Nature*, vol. liv, p. 263). Finally, having got together a considerable amount of more perfect material, I incidentally described the fish in my recently published memoir on the Silurian Fishes of Scotland, giving a restored figure of its dorsal aspect, which Dr. Smith Woodward has reproduced in his critical notice of that memoir which appeared in the Geological Magazine for February last. The conclusion I came to was that *Drepanaspis* formed the type of a distinct family, related not only to the Pteraspidæ but also to the Psammosteidæ and Cœlolepidæ, and which must consequently along with these three families be included in the Heterostraci, of which the Cœlolepidæ appear to form the starting-point.

But beyond the fact that *Drepanaspis* possessed a large median ventral plate as well as a dorsal one, and that the two could readily be distinguished by their shape, my knowledge of the topography of the inferior surface of the carapace was still imperfect. Nor had I ascertained the position of the mouth, though I said that "as it is impossible to conceive of the absence of a mouth, we must conclude that it was placed exactly at the anterior margin."

However, since that memoir was published, I have received from Dr. Krantz, of Bonn, a specimen of the carapace of *Drepanaspis* (Fig. 2), which not only clears up previously unsettled questions regarding the arrangement of the plates on the ventral surface, but also shows the mouth itself *in sitû*.

But before describing the ventral surface, I may as well recapitulate the facts already known regarding the configuration of the fish.

The carapace (Fig. 1) is broad, depressed, very obtusely rounded in front, and terminating behind in a prominent though rounded angle on each side. There is on the dorsal surface a large median plate (*m.d.*) of an ovate-hexagonal shape, the anterior margin being short and nearly straight, while the still shorter posterior one is acutely notched. Each postero-lateral angle of the carapace is formed by a narrow, elongated, somewhat falciform plate (*p.l.*), the postero-lateral or cornual, which tapers to a sharp point in front and forms most of the external margin of the shield. The rest of the

surface is formed by small polygonal plates, reminding us of the tesselated surface of many Psammostean shields, while we sometimes find a few larger *rostral* ones (*r.*) just at the anterior margin; and external to these just at the edge of the carapace we find a plate showing a small round depression or pit (*x.*) which in my Silurian memoir I have supposed might possibly represent an orbit. But to this I shall again refer further on.

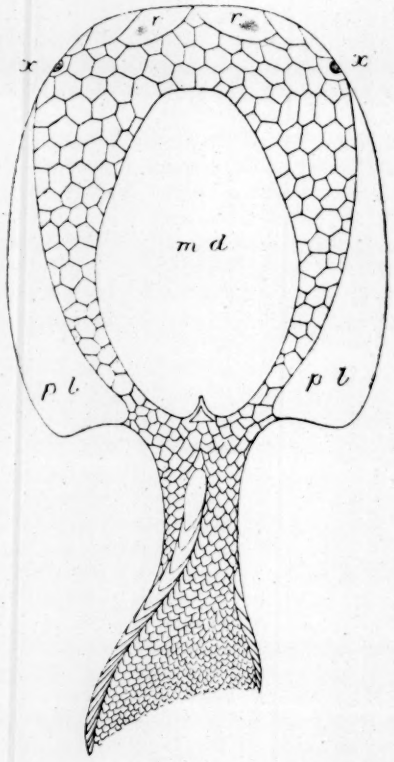

FIG. 1.—*Drepanaspis Gmündenensis*, Schlüter; restored outline of the dorsal aspect, the surface ornament omitted, and the tail twisted round so as to show the caudal fin in profile. *m.d.* median dorsal plate; *p.l.* postero-lateral plates; *r.* rostral plates; *x.* sensory plate. Slightly altered from the figure previously given.

The surface ornament of all these plates consists of small and tolerably closely set stellate tubercles, and it is to be noted that on the small polygonal ones we often find a tubercle of larger size at or near the centre, as is commonly the case on the polygonal areas of *Psammosteus Taylori*.

The tail, springing from the middle of the posterior margin of the carapace, is comparatively short, and terminates in a heterocercal

though scarcely bilobed caudal fin, but there is no trace of any other fins or appendages, paired or unpaired. These parts are covered on the sides by rhombic tuberculated scales, and bordered above and below respectively by a single row of narrow imbricating median scales or 'fulcra.' Nothing resembling *fin-rays* can be seen, nor is there any definite line of demarcation between the scales of the body prolongation and those of the fin-membrane, though the latter become gradually smaller.

Turning now to the ventral surface of the animal, I have in Fig. 2 given an accurately reduced sketch of the plates as seen in the new specimen to which I have alluded, while Fig. 3 represents a restoration in which the oblique distortion due to slaty cleavage

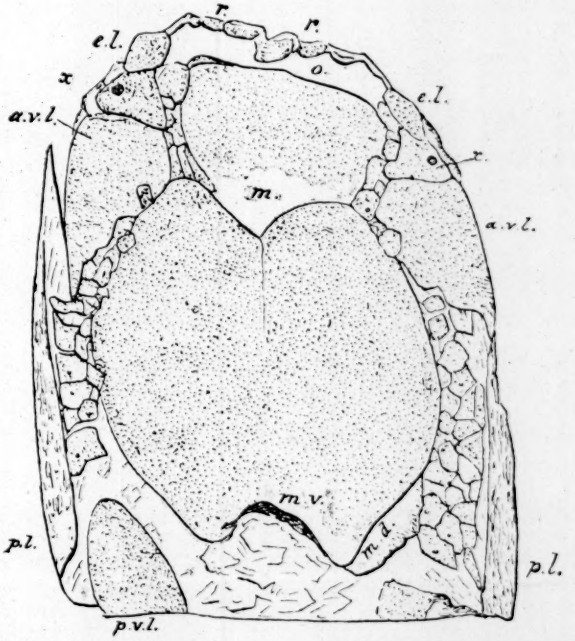

FIG. 2.—Sketch of a specimen of the carapace of *Drepanaspis Gmündenensis*, Schlüter; one-third natural size; distorted by slaty cleavage, and somewhat imperfect behind. *o.* mouth; *r.* rostral or upper labial plates; *e.l.* external labial plate; *m.* mental plate; *x.* sensory plate; *a.v.l.* anterior ventro-lateral; *m.v.* median ventral; *m.d.* portion of inner surface of median dorsal; *p.v.l.* posterior ventro-lateral; *p.l.* postero-lateral or cornual plate.

has been corrected. We may now see that the mouth (*o.*) is placed exactly where I had expected to find it, namely, at the anterior margin of the carapace. It is a transverse slit, the upper margin of which is formed by the anterior edges of the *rostral* plates (*r.*) already mentioned, while at each outer corner there is a small *external* labial plate (*e.l.*), the tubercles on which are rather larger than those

elsewhere. The lower boundary of the oral slit is formed by the lower margin of a broad pentagonal plate (*m.*), which we may call *mental.* The anterior or oral margin of this plate, which is also the longest, is, however, not quite straight, as it shows a very obtuse angle in the middle; the two lateral margins are shorter and slightly convergent posteriorly; the postero-lateral margins follow, each at an obtuse angle to its respective lateral one, and they meet each other behind also at an obtuse angle, which fits into the wide anterior notch or excavation of the plate next to be described.

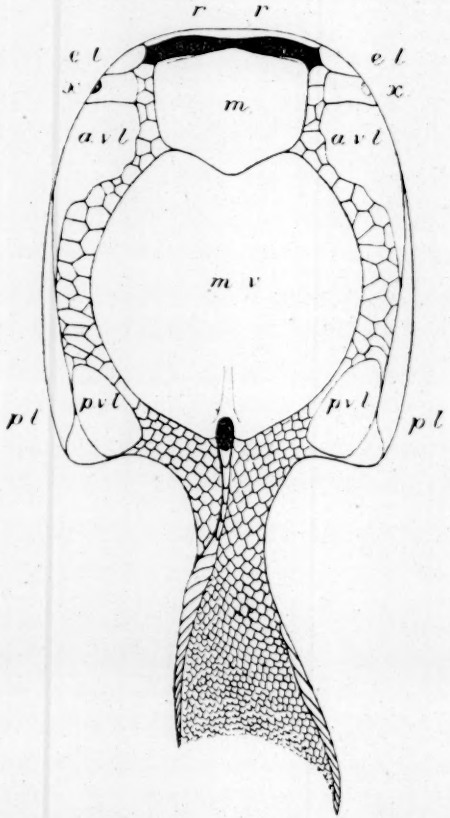

FIG. 3. — Restored outline of the ventral aspect of *Drepanaspis Gmündenensis*, Schlüter; surface ornament omitted, and the tail twisted round so as to appear in profile. Lettering as in Fig. 2, but the mouth in front and the supposed cloacal opening behind are represented in black.

This, the great *median ventral* plate (*m.v.*), is of a broadly oval form, having a widely open notch or indentation in front which, as aforesaid, receives the posterior angle of the mental plate. In the specimen of which Fig. 2 is a sketch, the hinder extremity of this plate is broken off, but in Fig. 3 I have restored its contour from other

specimens, whence it will be seen that it presents a narrow median notch, the direction of which is continued for a little way in front by a longitudinal fold-like elevation of the surface.

Returning now to the front, we find on each margin of the carapace, immediately behind the small external labial plate of the mouth, another and rather larger element of a trapezoidal shape (*x.*), transversely placed, with a short external margin, a longer internal one, while the posterior is the longest and is directed nearly at a right angle to the middle line of the creature. In the outer extremity of this plate is a small rounded depression, which in the specimen sketched in Fig. 2 and in some others is seen on the ventral aspect of the fossil; but as it also appears in some on the dorsal aspect it appears to me to have been marginal, and that the outer extremity of the plate on which it occurs must have been reflected upwards when in an uncrushed condition. In my "Silurian" Memoir above quoted, I have designated this depression as an orbit with a query, and it certainly occupies a position singularly analogous to that of the supposed orbit in *Pteraspis*, which is also very small in proportion to the size of the animal. But in some examples before me it seems to have a floor furnished with tubercles similar to those of the rest of the surface, so that its orbital nature can hardly be maintained. However, from its constant occurrence on the same plate and in the same position it must have a meaning, and doubtless it marks the place of an organ of sense of some sort, which can hardly be a nostril, and as the plate itself must have a name we may call it the *sensory* plate.

Immediately behind this 'sensory' plate is another and larger one (*a.v.l.*) of an approximately triangular form, a long irregularly scolloped side internally, a gently convex outer one, and an acutely pointed posterior angle. The outer margin of this plate, which we may call *anterior* ventro-lateral, fits on below the anterior pointed extremity of the great postero-lateral plate (*p.l.*), so extensively seen on the dorsal surface (Fig. 1), but which appears on the ventral aspect simply as a rather narrow thickened margin, marked with wavy ridges instead of tubercles, and is obliquely bevelled off just at the postero-lateral angle (Figs. 2 and 3). These lateral elements on the ventral surface are on each side separated from the mental and median ventral plates by a series of small polygonal ones, as represented in Figs. 2 and 3, but just behind there is an ovate-oblong one of a considerable size (*p.v.l.*), which may be called *posterior ventro-lateral*. The space between this and the postero-external angle of the plate *p.l.* (left empty in the figures) seems in one specimen to be covered by another smaller one; any way, I think that in this region the branchial aperture must have been placed, though its position is as yet not exactly determined.

In a specimen in the collection of the Geologische Landesanstalt in Berlin, the posterior notch of the median ventral plate seems to form, along with an elevated median scale just behind it, a narrow opening, which I take to be the orifice of the cloaca (see Fig. 3). This is succeeded in the backward direction by four similar scales

which pass into the median fulcra of the ventral margin of the tail and caudal fin; these fulcra being at first very stout and prominent, but becoming further back proportionally more slender and oblique.

The above is a sketch of the configuration of *Drepanaspis* and of the parts forming its exoskeleton, so far as I have been able to elucidate the subject after ten years' careful hoarding up of material.

Observations.—It will, I think, be acknowledged that *Drepanaspis* is a creature, the details of whose structure as described above form an important addition to our knowledge of the extinct Ostracodermi of the Silurian and Devonian periods. Its resemblance to the still imperfectly known Psammosteidæ cannot be gainsaid, nor can its affinity to the Cœlolepidæ on the one hand and to the Pteraspidæ on the other be doubted, and consequently I have in my memoir on the Scotch Silurian fishes included all four families in a new and enlarged conception of the Heterostracous division of the Ostracodermi.

Looking at *Drepanaspis* by itself we have a creature whose hard parts are entirely dermal, and in which no traces whatever of any endoskeleton can be found.

The mouth is a transverse slit, which shows no teeth, nor any jaws properly so called, and therefore affords an apparent support to the agnathous theory of the Ostracodermi. But, I repeat, we know nothing of the original cartilaginous endoskeleton, and consequently to believe that the fish while living had no cartilaginous representative of the Meckelian element is surely an assumption, while to argue therefrom any special affinity to the Lampreys, so utterly different in form, seems to me to be a *non sequitur*. Here it may be observed that the condition of the nasal organ does not afford us any help in this question, as no external nostril, either single or double, has been observed in *Drepanaspis* or in any other Ostracoderm. The only Palæozoic fish which is apparently monorhinal like the Lampreys is *Palæospondylus*.

There is certainly no shoulder girdle in *Drepanaspis*, nor are there paired fins, at least from the functional standpoint. But the prominent postero-lateral angles of the carapace are obviously equivalent to the lateral expansions in the Cœlolepidæ, which I have interpreted as pectoral fin-folds. If this idea is right, we have the parts representing the pectoral fins in *Drepanaspis* replaced by unyielding plates.

Dr. Smith Woodward, in his review of my Silurian memoir, disagrees with this view on two grounds.

First, because there is no line of demarcation between the fin-like expansions of *Thelodus* and the rest of its body, no change in the character of the dermal armature at that part, and no signs of flexibility.

But the very same things may be said of the *caudal fin* of *Thelodus* and of *Drepanaspis*, and surely no one would deny that *it*, at least, is a fin. In *Drepanaspis*, as we have seen, the expanse of the caudal fin is covered with scales precisely similar in shape and in sculpture to those of the body prolongation, between which and the fin

membrane no abrupt line can be seen, though the scales tend to diminish in size distally. And in a specimen of the recent Angel-fish (*Rhina squatina*) now before me, I see no sudden change in the character of the shagreen granules as they pass from the surface of the body on to that of the broad pectoral fin. As regards evidence of flexibility, the Silurian specimens of Cœlolepidæ are all crushed absolutely flat, but in the case of the large *Thelodus Pagei* from the Forfarshire Old Red, which has not been subjected to such an extreme degree of compression, it does seem to me that there is decided evidence of flexibility, as well as thinness, at the posterior external angles of the parts which I have supposed to represent fins.

Secondly, Dr. Smith Woodward objects to the idea of "a motile organ, originally used for balancing, if not for progression, losing its function, not by atrophy, but by conversion into a rigid structure continuous with its base of support," a phenomenon for which he has "tried in vain to find a parallel in the animal kingdom."

It is perhaps a bold idea, and I may be wrong, but let us look for one moment at the case of the Asterolepids (Antiarcha of Cope). Dr. Smith Woodward thinks it improbable that the pectoral members of *Pterichthys* are homologous with those of the 'Class Pisces,' but there they are, organs which must have been used for progression, enclosed in rigid plates, though provided with two joints, one at the junction with the body and another about the middle of the appendage itself. Dr. Smith Woodward maintains, however, that the *fixed* pectoral spines of *Acanthaspis*, which he considers to be an Asterolepid or Antiarchan, are homologous with the moveable 'arms' of *Asterolepis* or *Pterichthys*. If he is right in this, would there not be something of a parallel here, unless we believe that the fixed spine has been the original condition from which the complex moveable limb of *Pterichthys* has been evolved, which is not very probable? This, of course, is not an argument upon which I can insist, seeing that I personally consider *Acanthaspis* to be, not an Asterolepid, but a Coccostean, closely related to *Phlyctænaspis*, Traq., the very similar pectoral spine of which Dr. Smith Woodward was himself the first to observe.[1]

It is, however, not the object of the present communication to enter into an exhaustive discussion of the disputable questions raised in my 'Silurian' Memoir and in Dr. Smith Woodward's comments thereon,—*that* I must defer to another time and another place. My purpose has been to complete the description of the remarkable Heterostracan genus *Drepanaspis*, according to light thrown on the subject by material acquired since the publication of the memoir to which I have so often referred.

[1] In *Coccosteus* itself the pectoral spine is so small that in my description of the skeleton of *C. decipiens* (Ann. Mag. Nat. Hist., Feb., 1890) I described and figured it merely as a process of the interlateral plate, from which it is, however, quite distinct. There certainly is a 'Bruststachel' in *Coccosteus*, but as it is not only very small, but absolutely fixed, it can hardly be called a 'Ruderorgan.'

III.—On the Age of the Later Dykes of Anglesey.

By Edward Greenly, F.G.S.

THE existence in Anglesey of a series of dykes later than most of the rocks of the island has long been known. Some of the more conspicuous ones were described by Henslow, many more appear on the map of the Geological Survey, and petrological descriptions were given some years ago (Geol. Mag., 1887–88) by Mr. Harker.

They have been hitherto regarded as of Post-Carboniferous but Pre-Permian age, on the ground that, while traversing the Coal-measures of the Malldraeth Marsh, one of them has been observed to terminate at the base of the overlying red strata. Sir A. C. Ramsay distinctly states that this evidence is derived entirely from the old coal-workings, and that at the time he wrote the red beds, regarded by him as Permian, were nowhere visible at the surface. ("Geol. N. Wales," 2nd ed., p. 266.)

Now, however, some of the red beds in question are exposed in the bottoms of the railway cuttings on either side of Holland Arms Station. The sections are shallow, the cuttings being grassed over to within a few feet of the bottom, but are tolerably clear where visible. The rocks seen are variable red sandstones and marls, often green-mottled with occasional thin beds of harder yellow and white sandstone and grey shale. While some of the types are such as elsewhere occur in the true Coal-measures, others are of well-known 'New Red' aspect, and might, as far as lithological characters go, be even of Triassic age.[1] They closely resemble the rocks seen on the old pit spoil-banks, among which I have found red sandstones with secondary outgrowths of quartz showing crystal facets, like the well-known rocks of Penrith and other localities. There are beds, moreover, containing fragments of chert in a dolomitic matrix, and some with rolled fragments of limestone; and due weight must still be attached to the statement that certain faults fail to traverse these red beds in the old coal-mines.

It appears, then, that while the question of the age of these rocks cannot be regarded as settled, there is no fresh evidence to upset, and some to support, the view of Sir A. C. Ramsay that they are of Post-Carboniferous age.

Now, in the cutting south-west of the station, these beds are seen to be traversed by two dolerite dykes, one on each side of the Holyhead Road, that on the north-east being about 50 feet and that on the south-west side about 110 feet in width. Their intrusive relations are clear, and one of the grey shales shows small spots and is perceptibly indurated near the dyke. They break up spheroidally, and although the bulk of the material of both dykes is quite decomposed, yet the spheroidal cores are not only hard but remarkably fresh and well preserved. The dyke on the

[1] Some of my former colleagues of the Geological Survey, who have lately had much experience of the Red Rocks of South Wales and the Midlands, kindly examined some specimens for me.

north-east side of the road is seen only in the cutting, but that on the south-west side (which I will call the Holland Arms dyke) has been traced to the E.S.E. for a distance of more than a quarter of a mile, retaining all its peculiar characters. In this short distance it passes from the red rocks of the cutting across a faulted belt of Carboniferous Limestone, then across a narrow belt of Ordovician shales, and from these into mica-schists belonging to the old complex. It traverses, indeed, nearly all the great rock groups of Anglesey, and passes, unaffected so far as can be seen, across two, if not three, main faults. Moreover, the two faults in question must be at least of Post-Carboniferous, and if Sir A. C. Ramsay's view be correct, of Post-Permian age.

It appears, therefore, that the dykes must be of much later date than has been hitherto supposed. The negative evidence of the old pit-workings, that they belong to a period between Carboniferous and Permian, loses its value in face of the positive evidence from the railway cutting,[1] and certainly no volcanic episode of that date is known elsewhere in Britain. It is conceivable, indeed, that they might belong to the Permian period itself, but this is very unlikely, even should the red rocks prove to be Carboniferous. No such regular system of N.W.–S.E. dykes is known in the Permian volcanic groups, and in any case we should hardly expect Permian dykes to pass across main faults of Post-Carboniferous date. Now the next period of volcanic activity within the British area is that of Tertiary time (Geikie, "Ancient Volcanoes of Great Britain," vol. ii, p. 107); and to that period, therefore, these dykes most probably belong.

In addition to the stratigraphical considerations above set forth, there are others that lend support to this view.

The petrological characters of the dykes are on the whole favourable to it rather than otherwise. While the majority are somewhat sub-basic dolerites, with andesitic selvages, there are a certain number of typical ophitic olivine-dolerites, of which the Holland Arms dyke is one. I have compared a slide of it and of one of the less basic dykes a short distance away, on the south side of the Holyhead Road, near the old Jerusalem Inn, with a number of slides of Tertiary dykes in the Jermyn Street collection, and there is no difficulty in matching them. The Holland Arms dyke itself resembles a dyke from Goat Island, Raasay, to mention a particular instance.

Mr. Harker, who has described these dykes (Geol. Mag., 1887, p. 409; 1888, p. 267; also "Bala Volc. Series Carnarv.," pp. 106–109, and "Petrology for Students," 2nd ed., p. 129), and who has had exceptional opportunities for studying the Tertiary dykes of Skye, writes me:—"Petrographical analogies would seem rather to support than to debar such a conclusion [viz., *as to their Tertiary age*]. The Menai Straits dykes are for the most part andesitic dolerites and augite-andesites, not rocks of very basic composition,

[1] It may be remarked in passing that the statements as to certain *faults* in the coalfield, if true, lose none of their importance as evidence.

and olivine is of exceptional occurrence. Dykes and other intrusions of the Carboniferous-Permian set elsewhere in Britain seem to be in general decidedly basic, and usually carry olivine. They might be matched among the Tertiary rocks of the Western Isles, which have a very considerable range of composition, basic and sub-basic; but the Tertiary dykes of the North of England are, as Teall has pointed out, mainly of andesitic nature."

On p. 215 of "British Petrography," Mr. Teall remarks on a rock from Holyhead Island as "a wonderfully fresh ophitic olivine dolerite. In its composition and state of preservation it differs so markedly from the 'greenstones' and approaches so closely to many of the Carboniferous and Tertiary dolerites that one is inclined to regard it as a rock of much later date."

The Holland Arms dyke presents two opposite extremes with regard to state of preservation. Much of the rock is decomposed to a sand,[1] and yet in the cores of the spheroids even such a mineral as

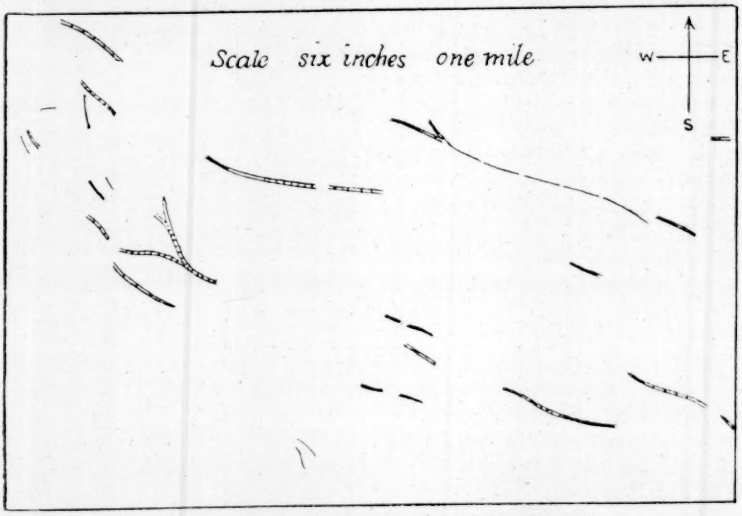

Fig. 1.—Group of dykes in Mynydd Llwydiarth.

olivine remains intact and unserpentinized to a degree almost unknown in Pre-Tertiary rocks. Mr. Barrow tells me that this condition is characteristic of the Cleveland dyke when traversing certain beds in East Yorkshire. The less basic dolerites are also in general very well preserved.

In their strike and general behaviour in the field these dykes closely resemble those of the West of Scotland; and certain parts of the maps can hardly fail to at least suggest to the mind that they belong to the same age and series of intrusions, the type of volcanic action being identical. (Fig. 1.) The average strike is about N.W.–S.E., a large number ranging W.N.W.–E.S.E., and a few in a more N.–S.

[1] Denudation along this soft friable material probably initiated the transverse ravine on the south side of the Holyhead Road at Holland Arms.

direction. The 'solitary' and 'gregarious' habits may both be said to be represented. The Plas Newydd dyke is a good example of the solitary, and the group shown in Fig. 1 of the gregarious type.

Most of them are short, or at any rate are traceable for short distances only, the longest yet mapped being the large dyke that runs from Menai Bridge village to Castellor, about a mile and three-quarters. The widest is the Holland Arms dyke itself, 110 feet, but the larger dykes of Menai Bridge, which average about 50 feet, are more typical of the larger dykes of the island. One of these last has been quarried for road-metal in several places, and the abandoned quarries remain as very striking trench-like chasms, one of which is visible from the Suspension Bridge among the houses on the north-east side. It may be observed, moreover, in this connection, that these dykes furnish the principal material for road-metal in the district.

The discontinuity of the dykes at the surface is not wholly due to concealment by drift, but can in certain cases be shown to be due to failure to reach the existing surface of the ground. Thus, the Menai Bridge dyke can be seen to be interrupted by a space of country rock near the Church, reappearing after a few yards. A small dyke (about 2 feet wide) at Cadnant Creek can be seen to terminate upwards in cross section (Fig. 2), while a large one on the coast

Fig. 2.—Upward termination of dyke at Cadnant.

near Careg Onen, sufficiently inclined to be of the nature of a sill (a somewhat rare mode of occurrence) is partly overlain by schist (Fig. 3), and disappears wholly underground before reaching low-

Fig. 3.—Sketch section through dyke near Careg Onen.

water mark. These characteristics were observed by Henslow, and are illustrated by him in some longitudinal sections. The Castellor dyke actually stops short at the brow of the hill overlooking the village of Menai Bridge, instead of, as might have been expected, being still better exposed in the lower ground. It is curious, though perhaps accidental, that the Cleveland dyke is known to behave in a similar manner (see Geikie, "Ancient Volcs. Gt. Brit.," vol. ii, pp. 147–150). Yet, in spite of phenomena like these, dykes cross the summit of Mynydd Llwydiarth at a height of 500 feet above the sea.

If the views advocated in this paper be adopted, considerable interest will attach to these rocks. The only igneous rock hitherto recognized as Tertiary in this country to the south of the Cleveland dyke is a solitary dyke which traverses the red rocks of Staffordshire.

But these Anglesey dykes are a large and important system, much more important than has been generally supposed. They do not give rise to conspicuous features of any kind, and easily escape notice, so that few of them have been hitherto recorded, except on certain parts of the coast. But within the space comprised in the one-inch sheets 94 and 106 (i.e. east of a line drawn from Pentraeth to near Plas Newydd) I have met with no less than 131. A large group also occurs about Holland Arms itself; and though they are less numerous in the centre of the island, a good many still appear, and of the same general type as those near the Straits; while Mr. Teall's remark above quoted shows that they also occur in the Holyhead area.[1] They are most numerous of all in the rocky tract known as Mynydd Llwydiarth (in Sheet 94), where 47 occur within a space of a square mile. But there is good reason to believe that they are as plentiful in the drift-covered areas as elsewhere, for the number of boulders they have furnished to the drift is out of all proportion to the known exposures, even allowing for their durability. Without supposing, however, that they are everywhere as numerous as on Mynydd Llwydiarth, it is not improbable that they average as many as ten to the square mile in Sheets 94 and 106, which estimate is as high as that given by Necker for the island of Arran (Geikie, op. cit., p. 124).

Volcanic activity thus appears to have been exerted in Tertiary times not only in North but in certain parts also of South Britain, and this serves to bring the British phenomena perceptibly nearer to those of the Continent. And if the phonolite of the Wolf Rock be, as would seem most probable, of Tertiary age, yet another link is added to carry us, in Tertiary time, across the tract of quiescence which still separates, though now even more widely than then, the volcanic regions of Northern from those of Central and Southern Europe.

IV. — On some Minor British Earthquakes of the Years 1893–1899.

By Charles Davison, Sc.D., F.G.S.

(*Concluded from the March Number, p.* 115.)

Cornwall Earthquake: Aug. 27, 1895.

THIS slight, though not uninteresting, earthquake was of intensity 4, and occurred at about 12.30 p.m. I have 20 records from 19 places, and negative records from 2 places.

The earthquake is chiefly remarkable for its small, but elongated, disturbed area (Fig. 2), which is 6 miles long, nearly 2 miles broad,

[1] Some basic dykes recently described from the north of the island do not appear to belong to the same series. (See C. A. Matley, Abstract Proc. Geol. Soc., Jan. 10, 1900, and discussion.)

and contains only 9 square miles. The direction of its longer axis is E. 5° N. and W. 5° S. The centre of the area is $\frac{1}{2}$ mile north of Blisland.

The shock was felt at 13 places. The sound was heard at all of these, and at 6 other places, 4 of which lie outside the disturbed area. The sound-area overlaps the disturbed area both to the north and south, but whether towards the east and west as well is doubtful; for, owing to the scarcity of observations, it is impossible to trace the boundary of the sound-area.

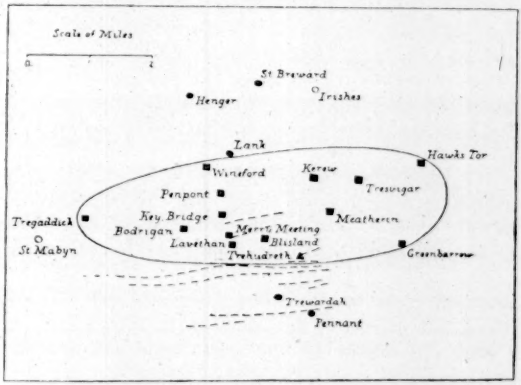

FIG. 2.—Cornwall Earthquake: Aug. 27, 1895.

In all parts of the disturbed area, the shock was merely a slight tremor, a shaking like that experienced on a bridge when a heavy weight is passing over it. At Greenbarrow, the earthquake was noticeable first as a low rumbling sound, growing louder until it resembled an explosion of gunpowder, causing a slight trembling of the floor and a little shaking of the furniture in the room.

The sound is described in 15 records, the comparisons being to passing trains, etc., in 33 per cent. of the number, to thunder (a long low peal of thunder) in 47 per cent., and to explosions in 20 per cent. The beginning of the sound generally coincided with that of the shock, and the end of the sound either coincided with, or followed immediately, the end of the shock. The epochs of maximum intensity of both sound and shock coincided, as is the rule in weak earthquakes. Several observers noticed a change in the character of the sound at the time when it was loudest. This is shown in the record from Greenbarrow quoted above. The evidence of an observer at Tregaddick is also worth giving. "The sound," he says, "was like that of an artillery waggon being trotted up to the house, and, when it apparently had arrived at the house, there was a noise as if two large stones were crunched against each other."

Origin of the Earthquake.—The only element of the originating fault that can be determined is its average direction, which is E. 5° N. and W. 5° S. The Geological Survey map shows no fault

anywhere near the disturbed area. Not far distant, however, there are several series of elvan dykes which have almost this direction. The broken lines on the map represent one of these series, and if one of the dykes, especially either of those which nearly coincide with the southern boundary of the disturbed area, should happen to run along a fault hading towards the north, it would satisfy all the conditions required by the seismic evidence.

The seismic focus must have been about 4 miles in length, and the displacement throughout extremely small. That the part from which the more prominent vibrations came was a narrow band is evident from the small breadth of the disturbed area. The extension of the sound-area on both sides of the disturbed area shows, I think, that the sound-vibrations came from the lower, as well as from the upper, margin of the focus; in other words, that the displacement died out downwards as well as upwards and laterally.

Cornwall Earthquake : Jan. 26, 1896.

The earthquake was a very slight one, of intensity 3 or nearly 4. It was felt at 6.50 a.m. The number of records is 36 from 30 places, in addition to which there are negative records from 20 places.

The disturbed area is 12 miles long and $8\frac{3}{4}$ miles broad, and contains 86 square miles. The direction of the longer axis is east and west, and the centre of the area lies $1\frac{1}{2}$ miles S. 42° E. of Launceston.

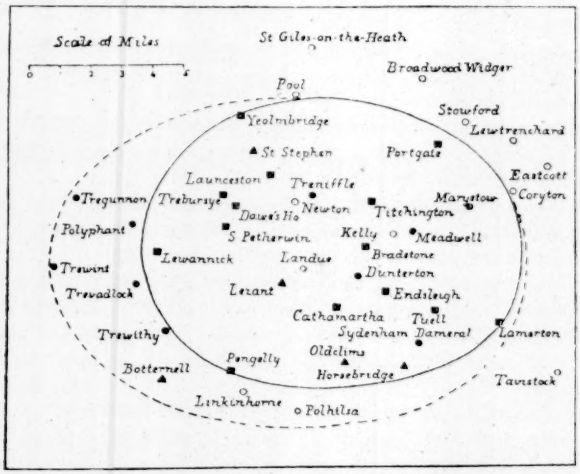

FIG. 3.—Cornwall Earthquake: Jan. 26, 1896.

The shock was felt at 14 places. At all of these the sound was heard, as well as at 10 places where the shock was not felt, and at 6 others where no mention of the shock is made. The sound-area is 15 miles long and 10 miles broad, and includes 124 square miles. Its longer axis is directed east and west, and is thus parallel to that

of the disturbed area. The centre is 1½ miles S. 12° E. of Launceston, and, as will be seen from the map (Fig. 3), the sound-area overlaps the disturbed area by 3 miles towards the west and by 1¼ miles towards the south.

Very few observers describe the shock. It was clearly a mere tremor, a dull shiver according to one, and a movement such as is produced in a building by a heavy peal of thunder according to another.

The sound was, as usual, a far more prominent feature of the earthquake. Comparisons to well-known sounds are made in 30 cases, in 27 per cent. of these to passing waggons, etc., in 57 per cent. to thunder, and generally distant thunder, and in 17 per cent. to explosions, which were, however, either prolonged or followed by a rumbling noise. Thus, the sounds must in all parts have lasted several seconds.

Origin of the Earthquake.—The longer axis of the disturbed area and sound-area agree in assigning an east and west direction to the originating fault. Its hade must be to the north, for the disturbed area is overlapped by the sound-area towards the south. The fault-line must therefore pass a short distance to the south of the centre of the disturbed area, possibly not very far from Dunterton, Landue, and Lezant.

The horizontal length of the seismic focus must have been about 5 miles, but the extension of the sound-area towards the west shows that the western margin of the focus was much longer than the eastern margin. The displacement throughout the whole focus was very small, and not much greater than that which will produce the sensation of sound.

In this case, again, the Geological Survey map provides no fault in the required position; but the early date of the survey should be borne in mind. To the south of the disturbed area there are, however, numerous mineral veins and elvan dykes, all of which run east and west, and therefore parallel to the earthquake-fault. If the district were to be carefully re-surveyed, a fault would no doubt be discovered that would satisfy all the seismic conditions.

Annandale Earthquake: May 29, 1896.

The disturbed area of this earthquake occupies a more populous part of Annandale than those of the shocks felt on March 8 and May 14, 1894. The number of records which I possess, is, however, small, only 15 from 14 places; but there are several other places from which negative records have come. The time of occurrence, as determined by a signalman at Castlemilk station, was 4.47 a.m.

The shock was distinctly felt at 7 places which lie within an area roughly circular in form and about 6 miles in diameter. The centre of the area is in lat. 55° 6′ N. and long. 3° 17′ W., and is equally distant (3 miles) from Lockerbie, Ecclefechan, and Minsca. The sound alone was observed at several places outside the boundary; at Craighouse close to the boundary on the south-east side, Dormont 1½ miles to the south-west, and Corsegreen 3 miles to the west.

Also at Castleo'er, 6 miles to the north-east, the sound was heard by two persons, and a faint tremor was felt by one of them. Probably all of these observations refer to the earthquake.

The shock lasted about 3 seconds, and was a mere quiver of intensity 4 at places close to the boundary above mentioned, which may therefore be regarded as an isoseismal of that intensity. Six observers compare the sound to some well-known type—three to distant thunder and three to the rumble of a passing cart or waggon.

On the Geological Survey map of the district, there is no fault marked anywhere near the required position. If the earthquake were due to a fault-slip, the approximate circularity of the disturbed area and the short duration of the shock show that the length of the seismic focus was small.

Glen Nevis Earthquake: June 5, 1896.

A slight shock was felt at an early hour in the morning, being strongest at Achreach. No mention is made of any sound accompanying the shock, but the account is very brief (*North British Daily Mail*, Glasgow, June 6). One of the seismographs at the Low-level Observatory at Fort William is said to have shown a very doubtful indication of the shock. The earthquake may have been due to a slip of the Highland fault, but there is no proof whatever of such an origin. If there were, it would of course furnish another indication that the hade of the fault in this district is to the south-east.

Rutland Earthquake: Jan. 28, 1898.

A slight shock of intensity 3 was felt about 10.5 p.m. over nearly the whole of Rutland and in small portions of the adjoining counties of Lincoln, Leicester, and Northampton. I have received 40 records of the earthquake from 26 places. For more than half of these accounts I am indebted to Mr. F. Coventry, of Duddington, who very kindly made many inquiries and distributed a number of my forms in different parts of the disturbed area.

In the map of the earthquake (Fig. 4), the boundary of the disturbed area is represented by a continuous line and that of the sound-area by a dotted line. Of the two the latter is probably the more accurately drawn, but it is impossible to feel much confidence in either, on account of the small number of determining places and the want of negative records. I made many inquiries, however, in the surrounding district, and the absence of replies is probably equivalent to non-observance of the shock or sound.

The disturbed area, as mapped, is 15 miles long, $12\frac{1}{2}$ miles broad, and contains 142 square miles. Its longer axis is directed N. 27° W. and S. 27° E. The sound-area overlaps the disturbed area by about a mile towards the south and three-quarters of a mile towards the east; its linear dimensions being 16 miles and $13\frac{1}{4}$ miles, and its area 165 square miles. The centre of the disturbed area is $1\frac{3}{4}$ miles E.N.E. of Oakham and coincides nearly with the village of Burley.

Wherever the earthquake was observed the sound was a far more prominent feature than the shock. The movement, when felt, was merely a faint vibration in the middle of the rumbling noise. In a few places it made glasses and crockery jingle slightly.

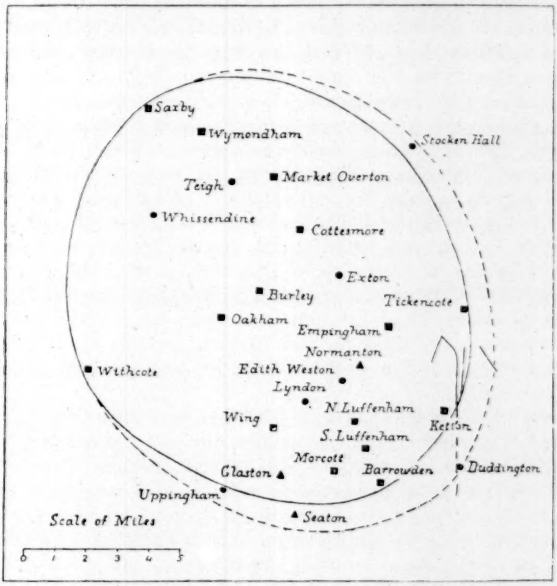

FIG. 4.—Rutland Earthquake: Jan. 28, 1898.

With the exception of one village, in which the omission is probably accidental, the sound was heard at every place where the earthquake was observed. Its gradual rise and fall in intensity are perhaps responsible for the frequent references to the passing of a heavy carrier's van, a train rushing over a long iron bridge, or heavy barrels rolled on pavement underneath the house. The sound is also compared to thunder or the continued tipping of a cartload of bricks. Every one of the ordinary types of earthquake sound is, however, employed, reference being made to passing waggons in 40 per cent. of the records, to thunder in 34 per cent., wind in 3, the tipping of a load of stones in 11, the fall of a heavy body in 3, explosions in 3, and to miscellaneous sounds in 6 per cent. The average duration of the sound appears to have been about 5 or 10 seconds; that it was not inconsiderable is evident from the frequent use of the longer types of comparison.

Origin of the Earthquake.—It is difficult to locate the originating fault with precision. Its general direction would appear to be about N.N.W. and S.S.E. The overlapping of the sound-area towards the east indicates that the fault hades to the west, as the sound-vibrations in the protruding part would come chiefly from the

upper margin of the focus. Thus, the fault-line should traverse the district between the centre of the disturbed area and its eastern boundary.

The faults of the district have been mapped by Professor Judd and described in his well-known memoir.[1] The more important ones have a W. by N. and E. by S. direction, with throws in some places of not less than 150 feet towards the north. The two chief faults are the Billesden and Loddington fault (traced for about 7 miles) and the Tinwell and Walton fault (about 14 miles in length), and between them are several others which have a parallel direction. Running transversely to these east and west faults are a number of others of smaller throw and with a general north and south direction, apparently representing cross fractures. A group of these is shown in the south-east corner of the map; one of which, passing by Ketton and Duddington, can be traced for a distance of 8 miles. Its throw seems to be greatest in the central part of its course, to the west of Collyweston; near Duddington it probably amounts to about 40 or 50 feet. At its north end it bends round to a north-westerly direction, and in this part its hade is evidently towards the west. The most easterly fault of the group runs about N.N.W. and S.S.E.

"That the faults mapped and described include all which traverse the area," Professor Judd remarks, "is by no means probable. Over considerable areas clays of enormous thickness prevail without any well-defined hard beds, and among these it would be impossible to detect dislocations while running the geological lines; other large areas are hopelessly concealed from our observation by thick masses of Boulder Clay, and of some of the faults actually detected it is not possible to trace more than a small part of their course, owing to the same causes." (p. 259.)

Possibly this may account for the termination on the map of the Ketton and Duddington fault towards the north, just after it crosses the river Wash and enters a mass of Lincolnshire Oolite. If the fault does not really end at this point, but is continued roughly in a N.N.W. direction, it would satisfy all the conditions implied by the seismic evidence. Whether it be to a slip of this fault, or of another transverse fault not shown on the Survey map, that the earthquake was due, it is clear that the displacement must have been very small to produce so slight a shock. The horizontal length of the focus may have amounted to two or three miles, and the displacement probably died out more slowly towards the south, giving rise to a broader lateral margin, and thus causing the sound-area to overlap the disturbed area in that direction.

Comrie Earthquake: Aug. 22, 1898.

To the seismologist, the recent Comrie earthquakes are of interest as members of a long series of shocks and sounds, now perhaps drawing for the present to a close. To the geologist, they may be of

[1] "The Geology of Rutland": Geol. Surv. Mem., 1875, pp. 256–259.

value from the evidence they furnish with regard to the hade of the great fault which forms the southern boundary of the Highlands. The study of a slight shock, which occurred on July 12, 1895, led to the inference that, in the neighbourhood of Comrie, the fault hades to the north-west;[1] and the still feebler shock of Aug. 22, 1898, supplies additional evidence in favour of this conclusion.

Many persons in the Comrie district seem inclined to refer the recent shocks to a desire to keep up the historic reputation of the village; and the exaggerated reports which have appeared in several newspapers certainly offer some excuse for this scepticism. Moreover, the weather on the last occasion was warm and sultry, the sound-area is very small, and it is therefore natural that many, who did not hear, or only just heard, the sound, should regard it as due to a peal of distant thunder. The seismic character of the disturbance cannot, however, be doubted after a careful study of all the evidence. The shock itself was felt by several persons (by two, as a vertical movement), the sound was evidently of underground origin, and other observers who are well acquainted with the tremors and earth-sounds of the district felt no hesitation in ascribing the sound to that of an earthquake too slight to be felt in all parts of the area affected.

The following account is based on 14 records from 8 places, and on statements that, at 12 other places, no sign of the earthquake was perceived.

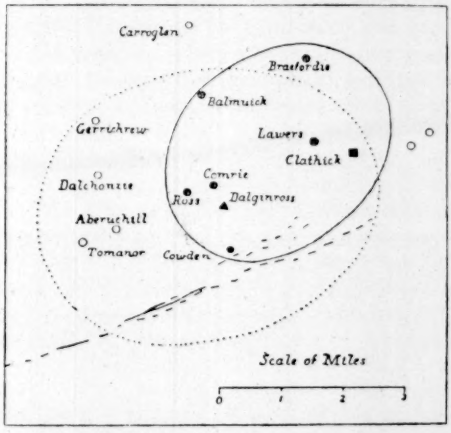

FIG. 5.—Comrie Earthquake: Aug. 22, 1898.

The earthquake occurred at about 7.15 a.m. The shock, which was of intensity 3, was felt only at Clathick, by three or four persons, and possibly by one person on the adjoining estate of Lawers. At Clathick, three distinct movements upwards and downwards were felt, as of heavy blows struck on the ground immediately beneath, lasting about 3 seconds. The sound was compared by four

[1] GEOL. MAG., Vol. III, 1896, pp. 75–79.

persons to distant thunder, and by one each to a cart coming up the road, to coals turned out of a cart, and to a distant quarry-blast.

The boundary of the sound-area is represented on the map (Fig. 5) by the continuous line; but, on account of the small number of observations, it cannot be regarded as very accurate, especially to the east of Clathick. The area, as drawn, is $3\frac{3}{4}$ miles long, 3 miles broad, and contains 9 square miles. Its centre is one mile E. 27° N. of Comrie.

Connection with the Earthquakes of 1894 *and* 1895.—The epicentres of all three earthquakes lie on the north-west side of the great fault, whose course is indicated by the broken lines on the map. The dotted line represents the isoseismal 3 of the earthquake of 1895. As we have seen, the epicentre of the 1894 earthquake was close to Comrie; in 1895, the epicentre must have been a mile or more in length, with its middle point a quarter of a mile south-west of Comrie. Thus, while the first two earthquakes originated in nearly the same region of the fault, the slip which caused the earthquake of 1898 took place at a spot about a mile further to the north-east, and apparently just outside the focus of the preceding shock.

As the epicentres must lie on the side towards which the fault hades, the three earthquakes agree in showing that, near Comrie, the hade is to the north-west.

Glen Garry Earthquake: Dec. 18, 1899.

As the records for these and preceding years have shown, slight earthquakes are not uncommon in the west of Inverness-shire, in Glen Garry and the tributary glens, but none seem to have been felt for more than five years, between Sept. 18, 1894, and the above date, when a stronger shock than usual occurred. It was felt at about 6.50 a.m. at Glenquoich, Glenkingie, Lochournhead, Carnich, and even as far as Corran (Arnisdale, in Glenelg), but the limits of the disturbed area cannot be ascertained owing to the scanty population of the district. On the south side of Loch Quoich the intensity of the shock was about 5. At Glenquoich a sound was heard like distant thunder, getting louder till the house trembled, and then the sound died away as if a carriage had passed; the sound lasted fully 17 seconds. In a neighbouring part of the glen, the sound was compared to a chimney on fire and afterwards to a very heavy carriage passing over an iron bridge, and at Glenkingie to a flock of sheep rushing over hard ground.

For the notices on the Glen Garry earthquakes described in this paper I am indebted to the kindness of Mr. D. Grant, of Glenquoich, Mr. A. M. G. Foster, of Glenkingie, and Mr. M. Matheson, of Ardochy, three very careful observers, who for many years have paid close attention to the subject. The value of their work can hardly be overestimated.

Doubtful and Spurious Earthquakes.

Monmouthshire, etc.: Jan., 1893.—In two letters in *Nature* (vol. xlvii, 1893, pp. 247, 270), Mr. E. J. Lowe, F.R.S., describes

a series of slight shocks. On the 3rd inst. he was sitting in a railway carriage placed in siding at Severn Junction station. At 2.15¼ p.m. he felt a sensible upward movement of the seat (as if pushed from below) and saw the carriage sway. The movement was from south to north, i.e. at right angles to the railway, and was repeated four times in about six seconds. At 2.17 p.m. there were two weaker movements. There was no train at the station, and the air was calm. Ice in the neighbourhood was said to have been cracked at the time. On Jan. 4, at 11 a.m., a heavy plant stage in a greenhouse at Itton Court, near Chepstow, was seen by two gentlemen to move four times. On Jan. 5, between 2 and 3 (?) p.m., and again on the 6th a little earlier, a rumbling noise was heard on the Black Mountains near Llanthony Monastery. On Jan. 14, at 6.55 p.m., a shock, lasting more than a second, was felt at Colesford (in Gloucestershire, a few miles from Monmouth) by a gentleman who had had experience of earthquakes in Japan.

Much fuller evidence than is here given would be required to establish the seismic character of these disturbances. An earthquake-shock strong enough to cause a sensible upward movement like that felt on Jan. 2 would be noticed over an area of many square miles, and could not fail to have attracted the attention of other persons. The rumbling noises near Llanthony may have been due to other natural or to artificial causes. It is clear that they cannot be placed in the same category as the Glen Garry earth-sound of Dec. 11, 1893, or the Fort William earth-sound of Jan. 9, 1895. In only one case were there two observers, and they were in the same house. I think, therefore, that the evidence is insufficient to enable us to regard them as other than doubtful, if not spurious, earthquakes.

Isle of Man: May 5–6, 1893.—A number of shocks were felt at nearly regular intervals on the days noticed, but there can be little, if any, doubt that they were due to the firing of heavy guns from H.M.S. "Neptune" (see *Nature*, vol. lx, 1899, p. 139).

Comrie: Feb. 27, 1894.—Reports of an earthquake on this day appeared in several daily papers, but were at once contradicted in the two journals published in Crieff. It is certain that an earthquake felt also, as alleged, at Ardoch and Buchanty (more than 8 and 10 miles, respectively, from Comrie) would have been widely observed. The weather, moreover, was stormy, and several peals of thunder were heard at the time at Comrie.

West Cornwall: May 29, 1896.—According to a paragraph in the *Standard* for the following day, a slight earthquake-shock was felt in West Cornwall at 6.55 a.m., and men on their way to work at the Camborne Mines felt the vibrations distinctly. I made many inquiries in the district, but none of my correspondents had met with, or heard of, any observer of the supposed earthquake. I do not think, therefore, that any reliance can be placed upon the report.

Through the kindness of several correspondents I have received reports of supposed earthquakes, but as I have been unable to obtain corroborative evidence, I have confined myself to noticing those which are recorded in journals that future seismologists would be likely to consult.

Earth-Shakes in Mining Districts.

Under this heading are included several shocks which, it is possible, may be of artificial origin, and, if so, ought to be regarded as spurious earthquakes. Formerly, I should have so considered them, but another explanation has recently occurred to me; and, if it be correct, it will be evident that they are partly artificial and partly natural in their origin. It therefore seems desirable to consider them separately.

Rhondda Valley.—The shocks referred to are frequently felt in the Rhondda Valley in Glamorganshire. One occurred on June 22, 1889,[1] and there have been at least three others within the period embraced by this paper, on April 11 and May 2, 1894, and October 16, 1896. Judging, however, from the expressions used by several of my correspondents, it is probable that these are the dates of only the more important movements.

The shock which occurred on April 11, 1894, at about 2.40 a.m., is described as one of the severest recently felt in the district; and making every allowance for exaggeration in the accounts,[2] there can be no doubt as to its intensity. At one or two places it cannot have been less than 5, that is to say, it must have been the strongest shock considered in this paper. Two loud reports, like those of cannon, were heard in quick succession, and at the same moments, or immediately afterwards, sharp vibrations were felt. They seem to have been almost equally distinct underground, for in several pits the miners rushed to the bottom of the shaft, thinking that a violent explosion had occurred. Notwithstanding the strength of the shock, however, the disturbed area was very small. So far as I have been able to ascertain, its boundary is almost exactly circular, about 5 miles in diameter, and with its centre $\frac{3}{4}$ mile east of Porth.

The second shock took place about noon on May 2, 1894, and seems to have originated in the same district. At the surface it must have been much slighter than the preceding shock; but underground it produced similar effects, miners in the same pits again leaving their work to escape from what appeared to be an explosion.

On October 16, 1896, the district affected was a very small one, not more than a mile in diameter, including Ystrad-y-fodwg, Pentre, Ton, and Gelli. At about 11 p.m. a loud boom, like the muffled sound of blasting, was heard, followed by a brief shaking. The sensation is described by most as like that experienced in a room immediately beneath another in which a heavy article of furniture had fallen. Miners at work rushed from one pit to

[1] Geol. Mag., Vol. VIII, 1891, p. 371.

[2] Houses are said to have rocked like cradles, etc. "Sir," said Dr. Johnson, when Boswell told him of the earthquake of Sept. 14, 1777, "it will be much exaggerated in public talk: for, in the first place, the common people do not accurately adapt their words to their thought: they do not mean to lie: but, taking no pains to be exact, they give you very false accounts. A great part of their language is proverbial. If anything rocks at all, they say *it rocks like a cradle*: and in this way they go on."

another, thinking an explosion had occurred. One informed me that a severe shaking was felt, the tools sprang from the floor and the dust rose in clouds off the bottom. Indeed, the shock seems to have been distinctly stronger underground than on the surface.

Kilsyth: Feb. 16, 1898.—Kilsyth lies in the valley of the Kelvin, 11 miles N.E. of Glasgow, and the same distance from Falkirk and Stirling. The supposed earthquake occurred at 1.33 p.m. It was felt and heard by hundreds of people in the town, but, though I have made many inquiries, I have received nothing but negative records from the surrounding country. It is therefore certain that the area affected must have been very small. All the accounts from Kilsyth are in agreement as to the nature of the shock and sound. There was a single movement, which immediately died away, lasting about a second; a dull heavy thud, as if some heavy article had fallen on the ground shaking all around. It was strong enough to make windows and crockery rattle, in one house to ring bells, and in others to throw down crockery from the shelves. The sound, which accompanied the shock, is said to have resembled the tipping of a load of coals, the fall of some heavy body, the slamming of a door, etc. Men working in the mines below were so alarmed that they ran to the bottom of the shaft.

Pendleton (near Manchester): *Feb.* 27, 1899.—With one exception, I am indebted for all the records which I possess of this supposed earthquake to the kindness of Mr. Mark Stirrup, F.G.S.[1] The shock was felt shortly after 10 p.m., according to one observer at exactly 10.1 p.m. The places at which the shock was felt are all within a small area, approximately circular in form, and about 4 or 5 miles in diameter. The centre of the area is about $\frac{1}{2}$ mile north of Pendleton, and lies a short distance on its downthrow side from the Irwell Valley fault. Even if we disregard the evidence of some observers as possibly exaggerated, there can be no doubt that the intensity of the shock was not less than 4, and it may have been as great as 5. A booming sound, like that of a gas explosion, accompanied the shock. In the Pendleton Colliery some falls of rock took place, and raised a cloud of dust which put some workmen's lamps out.

Origin of the Earth-Shakes.—There are certain features which are common to all the earth-shakes here considered, and which distinguish them from most ordinary earthquakes. They are:—

(1) The disturbed area is small; in the strongest, it is not more than about 5 miles in diameter.

(2) The intensity of the shock is very great for so small an area, and dies away rapidly from the centre towards the boundary.

From these facts, we conclude that the depth of the centre of disturbance is very small, and the inference is supported by the obviously great intensity of the shocks as felt in mines. Again:

(3) The shock and sound are of very short duration. The brevity of the sound is strikingly illustrated by the type of comparison

[1] See a paper by Mr. Stirrup on "The Earthquake of February 27th, 1899": Manchester Geol. Soc. Trans., vol. xxvi, 1899, pp. 174–178.

usually employed in describing it. Taking the four earth-shakes together, we find that 6 per cent. of the sound comparisons are to thunder, 12 to a load of stones falling, 35 to the fall of a heavy body, and 47 to explosions. Now, in the slightest earthquakes, such as those described in this paper, the corresponding percentages are 31 to passing waggons, etc., 35 to thunder, 3 to wind, 8 to a load of stones falling, 5 to the fall of a heavy body, 14 to explosions, and 4 to miscellaneous sounds. But it is only in isolated earthquakes that this is the case. The earth-sounds following a great earthquake or the sounds which accompany the weakest after-shocks resemble those caused by explosions or the fall of a heavy weight.[1]

It follows from this that the centre of disturbance must have been very small in the case of every one of the earth-shakes; and this conclusion is confirmed by the small size and the approximate circularity of the disturbed areas.

These two conclusions regarding the small depth and size of the centre of disturbance are strongly in favour of a local origin of the shocks. In the Rhondda valleys they are generally, I believe, attributed to rock-falls in old mine-workings; and this is no doubt the origin of some of the shocks, for such falls from the roof are known to occur and to lead to a subsidence of the ground above. The chief difficulty in accepting this explanation for the recent disturbances arises from the absence, so far as known, of any fallen masses.[2] The Kilsyth earth-shake was referred without hesitation by one of my correspondents to a blast in one of the whinstone quarries in the town; but, as another points out, the blasts have occurred daily for twelve years without any suggestion of an earthquake. Others, including several miners, consider that the shock was caused by a fall of rock in one of the old pit-workings by which the ground below is honeycombed. The shock at Pendleton is apparently, though not distinctly, ascribed by Mr. Stirrup to a slip of the Irwell Valley fault, and the proximity of the fault to the centre of disturbance is a point in favour of this theory.

But this, of course, is not a peculiarity of the Pendleton coal-mines. The beds about Kilsyth are cut up by a series of faults, and in the Rhondda Valley faults pass close to the centres of the disturbed areas of the earth-shakes. Perhaps a more significant fact is that the coal-seams are generally worked right up to the fault. This is certainly the case, as Mr. Stirrup informs me, at Pendleton, and it is probably so at Kilsyth and in the Rhondda valleys.

Now, by the withdrawal of the coal, the rock above is deprived to a great extent of its support, and tends gradually to sink down and close up the worked-out seam. Nowhere can this tendency be greater than where the rock is severed by a fault from that which adjoins it. Here the sinking would take place by a series of fault-slips, each of which might give rise to a rather strong shock on the surface of the ground above. But, as the slip would only affect

[1] Phil. Mag., vol. xlix, 1900, p. 58.
[2] *Nature*, vol. lx, 1899, p. 140.

a small region of the fault-surface and would occur at a slight depth, the intensity of the shock would rapidly fade away from the epicentre; the disturbed area would therefore be small and circular in form; and the shock and sound would be of brief duration, and in many ways resembling those produced by the fall of a heavy mass of rock.

If this is a correct explanation of some of the earth-shakes which occur in mining districts, it follows that such cannot be classed either with true or with spurious earthquakes. They are of natural origin in so far as they are produced by fault-slips, but artificial in that the slips are brought about by human labour and not by the slow and gradual cooling of the earth.

NOTICES OF MEMOIRS.

Note on *Belinurus grandævus*.[1]

In a review of a paper by Professor T. R. Jones & Dr. Henry Woodward on *Belinurus grandævus*, a new species of Palæozoic[2] Limuloid Crustacean from the 'Eo-Carboniferous' of Riversdale, N.S., it is stated on p. 208 of this journal that *Belinurus* has not been found in rocks of earlier age than the Coal-measures. In Geikie's Text Book of Geology, however, this genus is mentioned as occurring with *Pterygotus*, *Bothriolepis*, *Coccosteus*, *Pterichthys*, *Glyptolepis*, and other typical Lower Devonian and Silurian forms in the Kiltorcan Beds of Ireland. Thus the inference drawn in the conclusion of this article that these rocks are Carboniferous does not seem to be sustained. May it not, on the other hand, be assumed that "The faunæ of the seas of the Lower Carboniferous, Coal formation, and Permian periods, both in Europe and America, present so great similarities that they may, in a broad view of the subject, be regarded as identical;"[3] while for 'Lower Carboniferous,' according to correlations of the fossils from these strata in New Brunswick and Nova Scotia made recently by Professor Kidston and Dr. David White, as recorded by Mr. J. F. Whiteaves in his "Address on the Devonian System in Canada,"[4] must we now say 'Lower Devonian'?

R. W. E.

REVIEWS.

I.—Geological Survey of Canada. G. M. Dawson, C.M.G., LL.D., F.R.S., Director. Annual Report (New Series), Vol. X. Reports A, F, I, J, M, S, 1897. 8vo; with plates and maps. (Ottawa: Dawson, 1899.)

THE present volume, like its predecessors, contains within its pages many proofs of the excellent organization as well as the enterprising spirit which controls and animates the operations of all branches of the Survey, and testifies once again to the

[1] From *The Ottawa Naturalist*, January, 1900, vol. viii, No. 10, p. 256.
[2] Geol. Mag., September, 1899, p. 388.
[3] Acadian Geology, p. 283.
[4] Section E, American Association, Columbus, Ohio, August, 1899.

wonderful resourcefulness and the scientific attainments so happily blended in the Canadian geologist.

The Summary Report (A) by the Director, Dr. G. M. Dawson, dated January, 1898, contains a brief record of the executive and office work of the department and of the organization and main results of the field-work up to the end of the year 1897. The reports which follow have, as usual, all been issued separately, prior to the completion of the general report.

The Director refers especially in his report to the rich discoveries of placer gold on the Klondike and its tributary streams in the Yukon District, verifying his forecast as to their great value published in 1889. More detailed geological investigations must be made before the question of the origin of the gold can be solved. A prolonged and uninterrupted wearing down, from a very early period in the Tertiary, of rocks containing auriferous veins may, in part, account for the great quantities of residuary gold now contained in the placers.

The operations of the field parties (to the number of fifteen) embraced the following widely extended regions, viz., British Columbia (2), North-West Territories, boring operations (2), Ontario (4), Quebec (1), New Brunswick (1), Nova Scotia (3), and Hudson Strait (2).

Experimental borings in petroleum-bearing rocks were undertaken in Northern Alberta (N.W. Territories) with results which pointed to the existence of an oil-field of great extent in that region.

Following the account of this work, which is given in much detail, are the reports of the officers responsible for the Museum, Herbarium, and Library of the Survey.

The first field report (F) is that of Mr. W. McInnes, on the geology of the area covered by the Seine River and Lake Shebendowan map-sheets, comprising portions of Rainy River and Thunder Bay Districts, Ontario. After describing the physical characters of the region, its principal rivers, lakes, waterfalls, wild animals, forest growth, etc., the author deals with its geology. The geological formations are as follows, in descending order:—

Surface deposits of glacial and lacustrine origin.
Animikie.
Steep Rock.
Keewatin.
Coutchiching.
Laurentian.

The most widely distributed of these is the Laurentian, which occupies more than three-fourths of the entire area. It is made up of granite-gneisses, which vary in composition according to the presence or absence of hornblende, and in the distinctness of their foliation. The typical rock is a biotite-granite-gneiss made up of quartz, orthoclase, plagioclase, and biotite, generally distinctly foliated and banded with finer and coarser layers. The non-foliated, central portion merges gradually, at varying distances from the edge of

the area, into well-marked gneiss, the latter evidently a phase of the granite produced by stress and incipient flow. The prevailing aspect of the rocks of the Coutchiching series in this section is that of stratiform, fine and coarse gneisses, the coarser intrusive through the finer. The finer gneiss is identical with the Coutchiching series of Rainy Lake and probably represents its eastward extension. The Keewatin is made up of a number of rock types varying from extremely basic, igneous masses and their derived schists, to acid quartz-porphyries and the schists produced by their shearing. The Steep Rock Series, occurring about Steep Rock Lake, are believed to be of later age than the greater mass of the Keewatin strata, as they overlie unconformably the rest of the Archæan, occupying a position below the Cambrian and above the great bulk of the Keewatin. The Animikie rocks, which occupy a limited area in the south-eastern corner of the region, overlie unconformably the Archæan rocks wherever they have been seen in contact. From their stratigraphical relations to the overlying formations further east on Lake Superior, they are believed to represent the lower beds of the Cambrian. They consist of black and green slates with calcareous and cherty bands.

The glacial geology and economic geology of the region are described, the minerals including iron, gold, and silver, with others in insufficient quantities to be commercially valuable.

Report I, by Mr. A. E. Barlow, deals with the geology and natural resources of the area included in the Nipissing and Temiscaming map-sheets, comprising portions of the district of Nipissing, Ontario, and the county of Pontiac, Quebec. It is accompanied by two maps, each on a scale of four miles to one inch. The area represented in each map measures seventy-two miles in length from east to west, and forty-eight miles from north to south, thus embracing an area of 3,456 square miles, or a combined area of 6,912 square miles. The several geological systems and formations represented in the region subjacent to the Pleistocene superficial deposits are as follows, in descending order:—

Palæozoic.	Silurian: Niagara.
	Cambro-Silurian: Trenton; Birdseye and Black River.
Archæan.	Huronian.
	Laurentian: Diorite-gneiss and granite-gneiss.

The Archæan rocks of the region may be separated into two great subdivisions, that of the so-called Lower Laurentian and the Huronian. The Laurentian is composed of a series of massive or schistose, and usually evenly foliated, crystalline rocks, the latter being commonly referred to as 'gneisses.' The latter are separable into two divisions according to the prevalence of orthoclase or plagioclase as the felspathic constituent. Of the two types, granite-gneiss and diorite-gneiss, the former is by far the most abundant, and often passes by insensible gradations into massive, reddish granite in which little or no trace of foliation can be detected.

The Huronian rocks are generally clastic in composition, appearance, and microscopic structure, in marked contrast to those of

the Laurentian. The breccia or breccia-conglomerate which lies at the base of the Huronian is the rock referred to by Logan and Murray as 'slate-conglomerate' or 'chloritic slate-conglomerate.' It is composed of angular, subangular, or rounded fragments of various plutonic rocks, of which a coarse, red granite is the most abundant. Diabases and diorites are also present. Throughout the area the Huronian, where fully represented, is separable into three distinct subdivisions, which are, in ascending order, as follows: (1) Breccia or Breccia-conglomerate, (2) Greywacke shale or slate, (3) Felspathic sandstone or quartzite.

The Palæozoic rocks contained in this area consist of outlying patches of the following formations: (1) Birdseye and Black River, (2) Lower Trenton, (3) Niagara. Some excellent illustrations of the scenery of the region surveyed, and plates of microscopic sections, accompany this voluminous report, to which two appendices are added, the first consisting of tables of elevations calculated in feet above mean tide water at Quebec, the second containing tables of Cambro-Silurian and Silurian fossils, with remarks upon them, drawn up by Dr. H. M. Ami.

Report J, by Mr. R. Chalmers, is on the surface geology and auriferous deposits of South-Eastern Quebec. It contains the results of observations made during the seasons of 1895, 1896, and 1897. The district included in the report extends from Lake Champlain and the Vermont boundary north-eastward to Montmagny county, and from the province line along the New Hampshire and Maine border north-westward to the plain of the St. Lawrence. A general study of the superficial deposits of the region was made, with special reference to the auriferous alluviums of the 'Eastern Townships.' To carry this out thoroughly the whole of the St. Lawrence Valley was examined in some detail, the glaciation and the distribution of the Boulder-clay were investigated, and the origin of the latter and of other superficial deposits traced out. The pre-Glacial, decayed rock materials, 'sedentary' and 'transported,' lying beneath the Pleistocene series, were also studied in the gold-bearing districts, as it is chiefly in these that the precious metal is found in workable quantities.

Gold was first discovered in South-Eastern Quebec on the Gilbert River about the year 1823. Many years afterwards (1866) a report by an expert employed by Sir W. E. Logan, at that time Director of the Geological Survey of Canada, was drawn up relative to the distribution of gold in the gravels and clays and gold-bearing quartz veins; since that time gold-mining has gone on intermittently and with varying success in the valleys of the Gilbert and Chaudière rivers and other parts of the district referred to in the report. Although the gold-bearing alluviums of South-Eastern Quebec have been worked and studied for more than half a century by geologists, mining engineers, and others, yet very little is known concerning the true source of the gold. Logan and Sterry Hunt regarded its origin as traceable to the materials derived from the disintegration of the oldest rocks of the region, viz., the crystalline schists of the

Notre Dame Range, belonging for the most part to the Quebec Group. Little progress has been made in a knowledge of its derivation since the time of these geologists, as practically no quartz-mining has yet been carried on. The author finally concludes that "the primary source of the gold of the 'Eastern Townships' seems to be the crystalline schists of pre-Cambrian or Huronian age, which were invaded by diorites and other intrusives and yielded material to the basal Cambrian conglomerates, and were also probably traversed by quartz veins. In the removal and transportation of sedimentary material by drainage waters, whatever gold was in the quartz veins, and in the products of rock decay, would be concentrated in channels or river-bottoms in the gravels in which it is found at the present day."

Dr. L. W. Bailey's Report (M) relates to the mineral resources of the Province of New Brunswick. Among metallic ores are included iron, in the forms of hæmatite, magnetite, etc.; copper, as native copper, and various sulphides; lead, as galena, usually slightly argentiferous; zinc, as blende; antimony; nickel sulphide, bismuth; and gold. To these are added, among substances affording combustible products, bituminous coal, anthracite, cannelite, albertite, petroleum, and peat. Among materials for construction are granite, freestone, slate, limestone and marble, gypsum, clays and sands, besides graphite, salt, infusorial earth, fireclay, etc. Many of these substances, especially the metallic ores, occur only in small amounts. The geological formations represented in the province include all the divisions of the geological scale from the earliest Archæan to the Trias; those formations, such as the Laurentian, Huronian, and Cambrian, which elsewhere usually produce metallic ores, and the Carboniferous formation yielding coal and related products, occupy the largest areas.

Referring to gold, Dr. Bailey says that its existence in profitable quantities remains to be proved, and that this can only be done by a prolonged and systematic prospecting of the areas in which it is likely, if anywhere, to be found. The question of the occurrence of coal is to be made the subject of a special report. There is no dearth of materials used in construction and of deposits of gypsum, limestone, clay, sand, and probably bog manganese. This is doubtless a valuable report, especially from the economic point of view; but our space does not admit of more than this bare outline of its contents. It is accompanied by a map of the province on a scale of 10 miles to 1 inch.

Mr. E. D. Ingall, assisted by Messrs. Denis and McLeish, contributes his annual report (S) on mineral statistics and mines, thus adding to the steadily increasing classified system of mining records. Noting some features of progress of mineral development in the country as a whole, Mr. Ingall says the grand total of 1897, as compared with 1896, shows an increase of nearly 27 per cent., and as compared with 1895 of over 30 per cent. This is almost altogether due to the metallic minerals, and amongst these gold, silver, copper, and lead are those showing the most marked advance,

due chiefly to the continued expansion of the mining industries of British Columbia, that province dividing the honours with the Yukon District in the matter of gold.

With this voluminous report the volume concludes, and we have only now to congratulate Dr. Dawson and his able staff on the results of their labours as set forth with so much completeness and wealth of detail. ARTHUR H. FOORD.

II.—CONTRIBUTIONS TO CANADIAN PALÆONTOLOGY. Vol. IV, Part 1. A Revision of the Genera and Species of Canadian Palæozoic Corals. The Madreporaria Perforata and the Alcyonaria. (Geological Survey of Canada.) By LAWRENCE M. LAMBE, F.G.S. Pages 1–96, plates i–v. (Ottawa, 1899.)

A REVISION of the Palæozoic Corals has long been a desideratum. Since the great works of Milne-Edwards and Haime, no comprehensive treatise has been produced, though the labours of De Fromentel, Lindström, Duncan, Hinde, Koch, and others in Europe, and Hall, Billings, and Rominger in America, and Nicholson on both sides of the Atlantic, have greatly extended our knowledge of many groups. It need scarcely now be maintained that to Nicholson science is deeply indebted for the initiation of methods of study in this complicated group of organisms whereby a fuller and more exact comprehension of their structure has been acquired than was possible to the earlier workers in this field of study. His work on the Palæozoic Tabulate Corals laid the foundation upon which all subsequent investigators have built, and the fact of his having made use of much American material gives a peculiar value to his writings for those who have to deal with the Palæozoic Corals of that continent.

In the work before us the genera and species of the Canadian Palæozoic Corals are redescribed, and "it is attempted to show that some forms hitherto considered of little value as regards the determination of the age of the deposits in which they occur, on account of their wide range in geological time, are capable of indicating definite horizons through the possession of distinctive structural peculiarities." Thus, as Rominger has observed ("Fossil Corals of Michigan," 1876), Cambro-Silurian (Ordovician) and Silurian species of *Favosites* have spiniform septa, while those of the Devonian have squamulæ. Again, it is found that the forms of *Halysites* of different geological horizons have distinctive characteristics which are apparently constant. A table (at p. 74) shows the distribution in time (from the Niagara to the Trenton), with the physical characters—shape of corallites, size of their tubes, septation, tabulæ, etc.—of *Halysites catenularia* and six varieties, illustrating this point.

With respect to distribution in time *Favosites Gothlandica* has a very wide one in Canada. It is recorded as occurring at many localities in the Niagara, Guelph, and Lower Helderberg formations, in divisions 2, 3, and 4 of the Anticosti Group, and in rocks of supposed Hudson River age at Stony Mountain, Manitoba. Its

regional distribution is also very considerable: it extends from the shores of the Gulf of St. Lawrence to the Saskatchewan River. Another species, widely distributed in time and space, is *Lyellia affinis*, occurring in the "Hudson River and Niagara formations, in the four divisions of the Anticosti Group, and in the Lower Helderberg Group," and ranging from the Island of Anticosti to the Saskatchewan River.

The detailed descriptions of the species and their mutual relations, distribution, and synonymy are all worked out by the author with great care, and he seems to have sounded his authorities at all points.

Though in respect to the classification of the Palæozoic corals we are, and perhaps shall ever be, on very debatable ground, yet it may not be amiss to take a survey of our present position in the light of the more recent attempts made in this direction. Haeckel ("Systematische Phylogenie der Wirbellosen Thiere") includes in his class Scyphopolypi the fossil Cnidarians, such as the Favositidæ, Chætetidæ, Auloporidæ, Halysitidæ, etc., which built the coral reefs of the Silurian, Devonian, and Carboniferous seas, and are generally assigned to the Tabulata. Nicholson, discarding the latter group as originally constituted, as containing an incongruous assemblage of forms, places the Favositidæ, Syringoporidæ, and Thecidæ in the Madreporaria Perforata, while the Helioporidæ, Heliolitidæ, Halysitidæ, Chætetidæ, and Auloporidæ are referred to the Alcyonaria ("Manual of Palæontology," Nicholson & Lydekker, vol. i). Von Zittel, in his "Grundzüge der Palæontologie," while affirming that the greater number of the typical Tabulata (Favositidæ, Syringoporidæ, Halysitidæ) show close relationship to the Hexacorallia, concludes that any definite decision as to their systematic position seems to be unattainable. On this ground, though retaining them as a suborder of the Madreporaria, he relegates them as an appendix to the Hexacorallia, and places *Heliolites* in the Octocorallia (Alcyonaria), its generally accepted position.

The uncertainty regarding the zoological status of the various groups enumerated above (excepting perhaps the Heliolitidæ) is not likely to be dispelled, unless evidence is forthcoming in the shape of a living reef-building coral whose affinities with the fossil reef-builders of the favositoid and other kindred types will satisfy the most searching investigation. Even the remarkable discovery by Mr. J. J. Quelch [1] of a living coral (*Moseleya*) of Cyathophylloid affinities does not seem to have carried with it evidence of such a convincing character as to shake the position of the Rugosa (or Tetracorallia) as a distinct group.

Much light is thrown upon the structure and affinities of the Heliolitidæ in a recent and valuable contribution to the subject by Professor Lindström (Kong. Svenska Vetenskaps-Akad. Handl., Bd. xxxii, No. 1). It is noticeable that the genus *Lyellia*, M.-E. & H., is rejected by Lindström on account of its similarity to *Propora*, M.-E. & H.

[1] Ann. Mag. Nat. Hist., vol. xiii (1884), p. 293; "Challenger" Reports, vol. xvi (1886), p. 110; see also Nicholson, in "Manual of Palæontology," Nicholson & Lydekker, vol. i (1889), p. 274.

In the present work the author's suppression of certain species is, we trust, done with sufficient justification. It is a proceeding which should be carried out with the utmost caution, because, however inconvenient a multitude of species may be to the systematist, their presence is a lesser evil than that which may result from the loss of information respecting the mutations which groups of individuals undergo, and which are best recorded and stereotyped under a specific or varietal name. The disadvantage of burying such records, so to speak, is of course very much lessened when there is abundance of material at the disposal of the palæontologist, in which case transition forms may be found to bridge over the gaps and to unite what had before been mistaken for independent forms. The following genera are included in this Revision :—

Favosites.	Syringolites.	Heliolites.
Alveolites.	Romingeria.	Plasmopora.
Cœnites.	Fletcheria.	Lyellia.
Cladopora.	Nyctopora.	Lyopora.
Michelinia.	Syringopora.	Protarea.
Striatopora.	Cannapora.	Stylarea.
Trachypora.	Halysites.	Tetradium.
Calapœcia.		

The illustrations are few, and though excellent, considering the mode of reproduction adopted, are more suitable for the text than for plates. The details, doubtless most faithfully rendered in the original drawings, are in some instances reproduced on too small a scale to give satisfactory results. Moreover, we miss representations of the entire corallum, which is inserted only in one instance (pl. v, fig. 4, ½ nat. size). Apertures of corallites, sketched in outline, with the tubular parts from which they proceed omitted, have a strange and unnatural appearance (plates i and iii).

We cannot commend the practice adopted by the author of employing two terms of measurement—one for the corallum, in inches ; the other for the individual corallites, in millimetres.

This work will be of especial value to students of the Palæozoic corals of North America, while other palæontologists may learn much that is interesting respecting variations in structure, both external and internal, so minutely and carefully recorded by Mr. Lambe from the rich material at his command.

Arthur H. Foord.

REPORTS AND PROCEEDINGS.

Geological Society of London.

February 16th, 1900.—W. Whitaker, B.A., F.R.S., President, in the Chair.

Annual General Meeting.

The Secretary read the reports of the Council and of the Library and Museum Committee for the year 1899. In the former the Council referred to the continued increase in the number of Fellows and the steadily maintained financial prosperity of the Society.

During 1899 the number of Fellows elected was 52 (exactly the same number as in 1898): of these 45 qualified before the end of the year, making, with 11 previously elected Fellows, a total accession of 56 in the course of the twelve months under review. During the same period, the losses by death, resignation, and removal amounted to 51, the actual increase in the number of Fellows being therefore 5.

The total number of Fellows, Foreign Members, and Foreign Correspondents, which on December 31st, 1898, was 1,336, stood at 1,344 by the end of 1899.

The balance-sheet for the year 1899 showed receipts to the amount of £3,991 14*s.* 4*d.* (including a balance of £1,076 0*s.* 8*d.* brought forward from the previous year), and an expenditure of £3,029 14*s.* 6*d.* (omitting the sum of £541 6*s.* 0*d.* invested in India 3 per cent. Stock). Among the items of non-recurring expenditure were £200 contributed by the Society, at the request of H.M. Office of Works, towards the cost of the improved lavatory accommodation at the Society's apartments; and £73 16*s.* 5*d.* expended in the publication of vol. iii of Hutton's "Theory of the Earth." The balance remaining available for the current year is £420 13*s.* 10*d.*

The Council announced that it was proposed to complete the extension of the electric lighting to the whole of the Society's apartments at an estimated cost of £250, and the Fellows were requested to sanction this expenditure.

The bequest made by Sir Joseph Prestwich of the sum of £800 had now become payable to the Society, owing to the lamented death of Lady Prestwich. An extract from Sir Joseph's will was read, citing the purposes to which this sum is applicable, but it was pointed out that, in common with other legacies, that to the Society will have to be to some extent abated and moreover will have to bear its own legacy duty.

Reference was made to the issue of the third volume of Hutton's "Theory of the Earth," and gratitude was expressed for the minute and reverent care with which the work had been edited and annotated by Sir Archibald Geikie.

The completion of vol. lv and the commencement of vol. lvi of the Society's Quarterly Journal was mentioned, and it was stated that the Council had decided to discontinue, for the present, the issue of index-slips.

In conclusion, the awards of the various Medals and proceeds of donation funds in the gift of the Council were announced.

The report of the Library and Museum Committee enumerated the increasingly extensive additions made to the Society's Library, and announced the completion by Mr. C. Davies Sherborn of the work of labelling and registering the type, and other important specimens in the Museum.

After the reports had been read, the President invited those to speak who wished to make any comment on the management of the Society. Dr. G. J. Hinde said that owing to the action of the Council in rejecting a motion which he had made to it, "that an

invitation be extended to Miss Elles to be present at the Annual General Meeting to receive the award which has been made to her by the Council," he had, as a protest, resigned his position on the Council and withdrawn his nomination to the new Council, then being elected. He contended that the giving of the Medals and Awards was not an official part of the business of the Annual Meeting, and that in refusing to invite a recipient of an honour to be present to receive it, solely on the ground of sex, the Council had acted against the custom of the Society.

The reports having been adopted, the President handed the Wollaston Medal, awarded to Professor G. K. Gilbert, F.M.G.S., of Washington, to Mr. Henry White, Secretary of the American Embassy, for transmission to the recipient, addressing him as follows:—Mr. White,—

For many years Professor Gilbert has contributed to several American publications papers of a most varied kind, some dealing with important subjects appertaining to the Geology of the United States and some with matters of still wider interest.

The same may be said of his series of reports, etc., to the Geological Survey of the United States, beginning with the well-known "Geology of the Henry Mountains," in which the volcanic structure known as a laccolite was first described, and a masterly summary of the principles of erosion was given. The Essay on the Topographical Features of Lake-shores, descriptive of the work of waves, of streams, and of ice, of the formation of deltas, of cliffs, and of terraces, naturally led up to the great monograph on Lake Bonneville, the tracing out of a former feature—whereof the present Great Salt Lake is the diminished representative, written in such a way as to make one almost feel that the old lake is there still.

Nor has Professor Gilbert neglected those more practical matters that press themselves on officers of a Geological Survey, for he has written also on the Underground Water of the Arkansas Valley; but the lake fever keeps with him, and has led him to take up the question of recent earth-movements in the region of the Great Lakes, on which we had an elaborate essay in 1898, leading to the conclusion that change is still going on, and pointing out the results that will occur if it continues.

We feel that Professor Gilbert is an honour to the Survey of which he has long been an officer, and a worthy successor of his countrymen, James Hall and J. D. Dana, as our Wollaston Medallist, for his work is not only American, but for the world at large.

Mr. White replied in the following words:—Mr. President,—

It has given me great pleasure, Sir, to attend this interesting meeting to-day, and to receive on behalf of my fellow-countryman, Professor Gilbert, the Wollaston Medal which has been awarded to him by the Council of this Society for important researches concerning the mineral structure of the earth—an honour which, as you have just pointed out, has hitherto been conferred upon two other Americans only, the late James Hall and the late J. D. Dana.

Particularly gratifying has it been to me, as I am sure it will be to all who know Professor Gilbert, to hear, from the statement which you have just read, how highly his work is appreciated by the Geological Society of London. He deeply regrets that it should not have been possible for him, owing to engagements of a pressing nature at home, to come here to-day and to receive this Medal himself, but I shall not fail to inform him of the very kind manner in which its presentation has been made, and of the applause which has greeted each mention of his name at this meeting.

I beg to thank the Council of this Society most sincerely, on Professor Gilbert's behalf, for the honour which has been conferred upon him, an honour which he highly appreciates, as does the United States Geological Survey, of whose staff he has been a distinguished member since its foundation in 1878.

Perhaps I may be permitted, as one who has been closely connected for many years past with the diplomatic relations between the United States and Great Britain, to

add that I always welcome with especial pleasure occasions of this kind, on which marks of appreciation are conferred by scientific Societies of one country upon eminent men of the other, as they not only tend to draw more closely together the people of Great Britain and America, but they demonstrate to the rest of the world that the two nations are working together for the furtherance of science, and consequently for the advancement of civilization.

The President then handed the Murchison Medal, awarded to Baron Adolf Erik Nordenskiöld, of Stockholm, to His Excellency, Count Carl Lewenhaupt, Minister for Sweden and Norway, for transmission to the recipient, addressing him as follows:—Your Excellency,—

Baron Nordenskiöld has given much of his time to the arduous work of Arctic exploration, having visited Spitsbergen twice, the first time in 1858, with Torell. Again, in 1868 he organized and started another Arctic expedition, and in 1872 he discovered the great masses of native iron of Ovifak, originally described to our Society as meteorites, and also brought home a large collection of fossil plants, from which we learnt much as to the long-past climatic conditions of the Arctic regions.

In 1875 he went up the Yenisei from the Kara Sea; three years later he first doubled the northernmost point of the Old World, and reached Japan in the latter part of 1879, making what is known as the North-East Passage.

In 1883 he undertook a second voyage into the interior of Greenland, adding largely thereby to our knowledge of its glacial conditions.

Among the records of these expeditions, his book entitled "The Voyage of the *Vega*," which has been translated into English, and from which we derive much information as to inland ice, glaciers, and icebergs, and his work on "The Second Swedish Expedition to Greenland," are notable.

We have also to thank him for giving us an English version of some of his work, chiefly in the pages of the GEOLOGICAL MAGAZINE, in vol. ix of which is a set of papers on the Expedition to Greenland in 1870, while in vol. ii of decade II we find the Lecture on the Former Climate of the Polar Regions, and in vol. iii a set of papers on the Geology of part of Spitsbergen and a discourse on the distant Transport of Volcanic Dust.

Both as an observer and as an organizer of expeditions of discovery has Baron Nordenskiöld earned our gratitude, of which this Murchison Medal is a sign.

His Excellency replied in the following words:—Mr. President,—

On behalf of Baron Nordenskiöld, I beg to express his deep gratitude for the great distinction conferred upon him by the Council of the Geological Society. I shall not fail to transmit the Medal at once, but I may perhaps be allowed to mention that I have been asked to present the accompanying cheque as a donation from Baron Nordenskiöld to the British Antarctic Fund. It is a great pleasure for Baron Nordenskiöld to have this opportunity of proving his good wishes for the success of this expedition.

The President then presented the Lyell Medal to Mr. John Edward Marr, F.R.S., addressing him as follows:—Mr. Marr,—

From 1876 onwards you have contributed fourteen papers to our Journal, most of them on the Geology of the Lake District and its borders, but two being on Welsh and two on European geology. Of these one may specially note those on the pre-Devonian Rocks of Bohemia, on the Stockdale Shales (done in conjunction with our lamented friend Nicholson), on the Shap Granite and its Associated Rocks (done with Mr. Harker), and on Limestone-knolls.

These papers that you have given us are enough to prove your power as an observer and a reasoner both in the field and at home; but you have also contributed much to the GEOLOGICAL MAGAZINE, often in association with other workers, and I may remark that the frequent coupling of your name with other names shows how your aid is valued and how well you can work with others. Nor is this all; other journals have been enriched by your pen, and you have added the following books to the literature of Geology: "The Classification of the Cambrian and Silurian Rocks," "The Principles of Stratigraphical Geology," and "The Scientific Study of Scenery."

Undoubtedly your long continuous service on the Council (from 1885 to 1899) has alone hindered us from thus acknowledging the value of your work until now.

The award of the Lyell Medal may bring an additional pleasure to you in that it has been given to Nicholson, with whom you have so often worked, and to Hughes, whom you have so greatly assisted in the teaching of geology at Cambridge.

We are proud to add your name to the list of Lyell Medallists.

Mr. Marr, in reply, said:—Mr. President,—

In thanking the Council for the very gratifying and unexpected honour which they have conferred upon me, I feel that they must have been influenced in their choice by personal considerations, as I have been so long among them. The Founder of the Medal stated that the recipient must have "deserved well of the science," which in the present case could only be so in that I have tried to do my best; I will endeavour, however, by working in the future, to "justify the honour."

You have mentioned, Sir, original work and teaching as qualifications. As regards original work, I have been singularly fortunate in the co-operation of the late Professor Nicholson, and in that of Mr. Harker and Mr. Garwood. As a teacher, I am glad to see two of my old pupils receiving awards on this occasion, as it shows how happy I am in the nature of my classes. But I feel that the teacher's influence must count for something, and I know it by experience, as a pupil of the Woodwardian Professor. I am glad to take the present occasion to bear testimony to Professor Hughes's guidance of his pupils' work—a guidance by no means exercised solely in the lecture-room.

As one who was brought up in Lyellism, and am still being brought up in it, I am unaffectedly glad that the Lyell Medal has been awarded to me. I do not use the term Lyellism in a narrow sense, as a crystallized set of tenets, which will ever retain the form in which they were left at the Founder's death. I regard it rather as possessing vitality, and as ever growing and spreading its seed, like a goodly tree.

In conclusion, while thanking you, Sir, for the kind words which you have used in presenting the Medal, I beg to call your attention to the fact that it is 25 years since you have shown me your first kindness, and that kindness has continued ever since. I am especially glad to receive the Medal from your hands.

In presenting the balance of the proceeds of the Wollaston Donation Fund to Mr. George Thurland Prior, M.A., of the Natural History Museum, the President addressed him as follows:—Mr. Prior,—

In the course of the last thirteen years you have contributed a number of papers to the Mineralogical Society, either alone or in conjunction with other observers, in which you have described minerals from various parts of the world. In the case, indeed, of one of the late numbers of the Mineralogical Magazine, there would be little left were the five papers wholly or partly written by you taken out. In three cases you have done us the service of showing that certain minerals had been christened more than once. You have, moreover, strayed from the path of pure Mineralogy into the ways of Petrology, and have always been ready to let geologists have the advantage of that valuable help which your position in the Natural History Museum enables you to give them.

We are glad to find that our great National Museum continues to keep to the front in Mineralogy, and that we may look forward to the continuance of able observers among its officials. The Wollaston Fund is most fittingly awarded to this end.

Mr. Prior replied in the following words:—Mr. President,—

I wish to express my heartfelt thanks to the Council for the honour which they have done me in conferring this award. That it should be connected with the name of Wollaston is to me an additional pleasure, since my work has been mainly of a chemical and mineralogical character.

Mineralogists are perhaps rather apt to pay too little attention to the modes of occurrence and mutual associations of the minerals that they study. To try in future to make my mineralogy more geological in its character, I feel, will be the best way for me to show my high appreciation of this generous recognition from the Council and of the kind words with which you, Sir, have accompanied it.

The President then handed the balance of the proceeds of the Murchison Geological Fund, awarded to Mr. A. Vaughan Jennings,

F.L.S., to Professor J. W. Judd, C.B., LL.D., F.R.S., for transmission to the recipient, addressing him as follows:—Professor Judd,—

Mr. Vaughan Jennings has done much work in Physical Geology and in Petrology, especially in the papers which he has given us on the country around Davos in Switzerland, and he has done this despite long and serious illness. Driven abroad by that illness, he has used the opportunity thus afforded to investigate the geological structure of the district in which he has had to live and to unravel the geological history of the great valley of the Engadin.

We hope that this award may not only show him that his work, done under such disadvantage, is appreciated by us, but may also cheer him in time of trouble and encourage him to continue his labours.

Professor Judd, in reply, said:—Mr. President,—

I wish to express my great regret that the state of Mr. Vaughan Jennings's health and the illness of a near relative prevent him from being present to receive the award in person, and therefore beg to read the following words of acknowledgment of the honour done to him:—

"In endeavouring to express my thanks to the Council of the Geological Society for the honour which they have conferred upon me, I feel that my remarks must be of an apologetic character. Though much of my time for many years has been devoted to geological matters, my contributions to original research in that science have been far less than I wished and hoped.

"The reason—or, perhaps, I should say, the excuse—for this, lies in an unfortunate interest in the sister sciences of Zoology and Botany, and in the fact that most of my time has been devoted to teaching. While most of the Fellows of this Society doubtless recognize, in theory, the value of an equal study of the three branches of Natural History, it must be difficult for many to realize the difficulty of putting the theory into practice, and the limitation which such an attempt must impose on one's efforts to do special work in any particular branch.

"The consciousness that I have been led astray into the mazes of Invertebrate Anatomy and the devious paths of Cryptogamic Botany, makes me feel still more grateful that geologists have recognized some slight value in my contributions to our knowledge of the earth.

"My first attempt in Alpine geology is almost certainly my last; but the Council may rest assured that their kind recognition of my efforts will encourage me to work, as long as I am able, for the advancement of our science in whatever way is possible. That I have been capable of accomplishing anything in this direction is chiefly due to my studentship at the Royal College of Science, and to the kindly help of those connected with that institution.

"Perhaps I may be allowed to express also my great regret that, by accident (as I was travelling during the final revision), no acknowledgment was made in my last paper of the kind and constant assistance vouchsafed to me by Professor Bonney during the progress of the work."

In handing the balance of the proceeds of the Lyell Geological Fund, awarded to Miss Gertrude L. Elles, of Newnham College, to Professor T. McKenny Hughes, F.R.S., for transmission to the recipient, the President addressed him in the following words:—Professor Hughes,—

After some stratigraphical work in the Lake District and in North Wales, done with Miss E. M. R. Wood, Miss Elles gave special attention to the Graptolites, and we have had from her a paper on the subgenera *Petalograptus* and *Cephalograptus*, adding much to our knowledge of the characters and range of those fossils, followed by the still more important paper on the Graptolite fauna of the Skiddaw Slates, in which, after a mass of descriptive details, the phylogeny of the group is treated of at some length.

This has been followed by a paper, as yet unpublished, in which her knowledge of the Graptolites is applied to the zonal classification of the Wenlock Shales of the Welsh Borderland. We hope that this award from the Lyell Geological Fund will show her that her work is valued and will encourage her to continue it.

Professor Hughes replied as follows:—Mr. President,—

I am glad to have been asked to receive the award from the Lyell Fund for transmission to Miss Elles, who is debarred by circumstances over which she had no control from standing here to receive for herself this mark of recognition which the Council of the Society have bestowed upon her.

The research by which she has won for herself a prominent place among geologists might seem of limited scope to all but a few who know the difficulty and the importance of the group of organisms to which she has chiefly devoted her attention.

I am much pleased, therefore, to be here to-day to testify that Miss Elles, who is Assistant Demonstrator in my Department at Cambridge, has shown herself to be a clear-sighted stratigraphist and an astute palæontologist over a much wider field than might appear from the mention of the work for which this award has been made, and that she is, besides, accomplished in other and altogether different branches of culture.

Miss Elles has asked me to communicate her thanks in the following terms:—

"Please convey to the Council of the Geological Society my warmest thanks for the great honour which they have so unexpectedly conferred in awarding to me the Lyell Fund for this year.

"I have been able to do so little as yet, that I am bound to regard it as an incentive to future work, rather than as a reward for anything accomplished. I can only add, that I will strive my very utmost to make the work which I may do in the future worthy of the confidence which such an award seems to imply."

The President then handed to Mr. George C. Crick, A.R.S.M., of the Natural History Museum, a moiety of the proceeds of the Barlow-Jameson Fund, addressing him as follows:—Mr. Crick,—

In the course of the last ten years you have made yourself an authority on Fossil Cephalopoda, and have contributed several papers on various branches of this subject to the Geological Magazine and other journals, among which one may note, as of high general interest, your long and well illustrated essay on the muscular attachment of the animal to the shell, published in the Transactions of the Linnean Society in 1898: a subject which had escaped the attention of palæontologists until you drew attention to it.

Your official work at the Natural History Museum has included the making of the List of Types and Figured Specimens of Fossil Cephalopoda and the preparation of vol. iii (in conjunction with Dr. A. H. Foord) of the Catalogue of Fossil Cephalopoda in that Museum, and you have kept up the high character of that public establishment for readiness to impart information to the inquiring geologist.

Mr. Crick replied in the following words:—Mr. President,—

I beg to express my sincere thanks to the Council of the Geological Society for the great and unexpected honour that they have conferred upon me: and to you, Sir, for the kind words with which you have accompanied the award. Considering the many privileges that pertain to my official connection with the British Museum, the amount of work which has been done by me is comparatively so small that I regard the award as an encouragement to continue my work, rather than as a recognition of that already accomplished.

In presenting to Professor Theodore Thomas Groom, M.A., D.Sc., the other moiety of the proceeds of the Barlow-Jameson Fund, the President addressed him as follows:—Professor Groom,—

While at Cambridge you gave us two papers on palæontological and petrological subjects, and since then we have had from you, together with Mr. Lake, a paper on the Llandovery Rocks of Corwen, in which special reference is made to the structure of the district. Carrying out this line of research, you have contributed two elaborate papers on the Geological Structure of the Malverns, one of which is but lately published; and in these you have shown your knowledge of some of the latest methods of stratigraphical research, and your power of applying them to the elucidation of important problems in a somewhat difficult district. I trust that this award may be an encouragement to you to continue your good work.

Professor Groom replied in the following words:—Mr. President,—

The scientific investigator has many and varied sources of pleasure: among the greatest of these must be reckoned the sympathies of his fellow-workers, and the appreciation of his efforts by those best qualified to judge. It is therefore with peculiar satisfaction that I understand from your kind words, and from the honour which the Council of the Geological Society have conferred upon me, that my work has met with approval.

The President then proceeded to read his Anniversary Address, in which he first gave obituary notices of several Foreign Members, Foreign Correspondents, and Fellows deceased since the last annual meeting, including Professor R. W. Bunsen (elected F.M. in 1856), Professor H. B. Geinitz (F.M. in 1857), Dr. Franz Ritter von Hauer (F.M. in 1871), Charles Brongniart (F.C. in 1888), Professor Louis Lartet (F.C. in 1882), Sir J. W. Dawson (elected a Fellow in 1854), G. Dowker (el. 1864), Sir William Flower (el. 1866), Sir Douglas Galton (el. 1848), T. M. Hall (el. 1865), Dr. H. Hicks (el. 1871), Sir Frederick McCoy (el. 1852), J. B. Redman (el. 1882), and John Ruskin (el. 1840). He also gave obituary notices of Major Lambart Brickenden, formerly for many years a Fellow of the Society, and of Lady Prestwich.

He then referred to the great advance in Geological Science in his own time, an advance that consisted largely of the arising of new lines of work and not merely of progress in old ones; thus Petrology was a new branch of the science. Palæontology had been affected by the growth of the Theory of Evolution. In Physical Geology such subjects as metamorphism, mountain-structure, and erosion had entered into new phases. In Stratigraphy the geological series had been extended downward below the Cambrian, and at the other end of the scale our knowledge of the Drift had greatly developed, largely owing probably to geological discoveries connected with the Antiquity of Man.

He then treated of the advance in our knowledge of Underground Geology, especially in the South-East of England, a subject in which comparatively little was known 45 years ago; and he described in some detail the underground extension and thickness of various formations, particularly of those below the Chalk, under the heads Upper Greensand, Gault, Lower Greensand, Wealden and Purbeck, Jurassic, Lias and Trias, and Older Rocks; referring to the amount of knowledge which we possess in the London Basin, and its southern border in the Wealden district, as compared with the Hampshire Basin.

He concluded that, as in the past such great progress had been made, so in the future would progress continue, with the development of new ideas and fresh methods of work, so that our younger geologists would have plenty of work before them.

The ballot for the Council and Officers was taken, and the following were declared duly elected for the ensuing year:—*Council*: W. T. Blanford, LL.D., F.R.S.; Professor T. G. Bonney, D.Sc., LL.D., F.R.S.; Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S.; E. J. Garwood, Esq., M.A.; Alfred Harker, Esq., M.A.; F. W. Harmer, Esq.; R. S. Herries, Esq., M.A.; Rev. Edwin Hill, M.A.; William Hill, Esq.; Professor J. W. Judd, C.B., LL.D., F.R.S.; Lieut.-General C. A. McMahon, F.R.S.; H. W. Monckton, Esq., F.L.S.; E. T. Newton, Esq., F.R.S.; G. T.

Prior, Esq., M.A.; F. W. Rudler, Esq.; Professor H. G. Seeley, F.R.S., F.L.S.; Professor W. J. Sollas, M.A., D.Sc., LL.D., F.R.S.; J. J. H. Teall, Esq., M.A., F.R.S.; Professor W. W. Watts, M.A.; W. Whitaker, Esq., B.A., F.R.S.; Rev. H. H. Winwood, M.A.; A. S. Woodward, Esq., F.L.S.; and H. B. Woodward, Esq., F.R.S.

Officers:—President: J. J. H. Teall, Esq., M.A., F.R.S. *Vice-Presidents*: Professor J. W. Judd, C.B., LL.D., F.R.S.; H. W. Monckton, Esq., F.L.S.; Professor H. G. Seeley, F.R.S., F.L.S.; and Professor W. J. Sollas, M.A., D.Sc., LL.D., F.R.S. *Secretaries*: R. S. Herries, Esq., M.A., and Professor W. W. Watts, M.A. *Foreign Secretary*: Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S., F.L.S. *Treasurer*: W. T. Blanford, LL.D., F.R.S.

CORRESPONDENCE.

THE GEOLOGICAL SURVEY OF EGYPT.

SIR,—In No. 427 of the GEOL. MAG., January, 1900, p. 46, Mr. H. J. L. Beadnell, in a letter entitled "The Geological Survey of Egypt," refers to an abstract report (in *Zeitschrift für praktische Geologie*, Berlin, November, 1899) of my lecture, "Neues zur Geologie und Paläontologie Aegyptens" (Allgemeine Versammlung d. Deutsch. geol. Ges., 1899, in München).

From this abstract report he concludes that I claim to have myself "discovered the existence of rocks of Cenomanian age in Baharia Oasis," which, in fact, I never visited. I never did claim such a thing in any way, as shown by the manuscript of my lecture, *not yet printed*, and I cannot possibly be made responsible for an abstract report, which, as everyone sees from its title and its contents, is not written by me but by Mr. Dieseldorff, the reporter of the *Zeitschrift für praktische Geologie*. In this paper the names of the geologists mentioned in my lecture have been left out in order to shorten it, and there are other mistakes besides which I am sorry I could not correct, because a proof was not sent to me for correction. The authentic words of my lecture will be published soon.

I desire to mention the following facts:—Although I did not myself find the fossils in the Cretaceous formation of the Baharia Oasis, yet I was the first to examine and recognize them as Cenomanian, and thus to prove the Cenomanian age of Baharia. Mr. Beadnell himself, who did not at all know the meaning of his fine fossils, was surprised by my discovery. This he will certainly not deny.

But as Mr. Beadnell justly sets a great value upon being named as discoverer of the fossils, I must claim the same right for myself with respect to the publication of notes in this Magazine on the Palæontology of Egypt. In the January number there is an essay, "On a New Species of Chelonian (*Podocnemis ægyptiaca*) from the Lower Miocene of Egypt," by C. W. Andrews, who describes some fossils collected by me at Moghara without anywhere mentioning my name.

I wish to act in the interests of my former colleagues in Egypt also by asking the palæontologists of the British Museum to mention in each instance the name of the discoverers of the fossils referred to.

M. BLANCKENHORN.

BERLIN.

[*Unavoidably delayed in publication.*—EDIT. GEOL. MAG.]